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CONTENTS

INFLUENCE OF CLIMATIC FACTORS ON THE GROWTH AND YIELD OF SPRING (*BORO*) AND SUMMER (*AUS*) PADDIES

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VERY few studies on the influence of climatic factors on the growth and yield of paddy have been made in this country. Khadilkar (1934) found some interesting correlations between some plant characters and weather factors, especially the rainfall and the maximum temperature during the growing period of the rice crop. Sircar and Sen (1951) have reported that the tillers of a winter variety of paddy, 'Rupsail', which came out between November and February, did not produce sufficient grains and a large number of unfilled grains was found, while the tillers that came out after February produced a large number of grains; they concluded that there is the critical temperature, i.e., 90° F. for grain formation for this variety, below which the flowers do not mature and form grains. Ramiah (1954) has discussed in detail the influence of temperature, latitude and day-length on the growth and yield of paddy. The present paper deals with the study on the effect of climatic factors such as temperature, humidity, rainfall, day-length, etc., on the growth and yield of some of the high-yielding varieties of *boro* and *aus* paddy.

MATERIAL AND METHODS

Seven varieties of *boro* paddy—Assam I, Assam II, Assam IV, D. I. 3, D. I. 4, Kakuria and Chinsurah Boro I—and three varieties of *aus* paddy—Dhairal, Marichbutti and Bhutmuri—were sown in both *kharif* (wet) and *boro* (dry) seasons to study the effect of climatic factors on the growth and yield of these varieties. The experiment was conducted for two consecutive years, with six replications, the unit-size of the plot being 1/130·2 acre.

The experimental area was ploughed thoroughly and nitrogenous fertilizers at the rate of 40 lb. per acre applied in two parts—half during the preparation of the field and the balance after one month of transplantation; 30 lb. P_2O_5 per acre was added once only during the final preparation of the field.

To record the data on tillering, height, length and breadth of flag leaf, at harvest ten plants of each variety were selected at random from each replication. Ear emergence note was taken. Data for grain and straw yield were also collected after drying them thoroughly in the sun.

RESULTS AND DISCUSSION

In 1953-54 during *kharif*, the tillers were counted only at harvest, while in *boro* they were counted after 50 and 78 days of transplanting and at harvest. In 1954-55 during *kharif*, the counting was done only twice—40 days after transplanting and at

harvest, and in *boro*, only at harvest. All the data were analysed statistically and found to be significant at one per cent level, except the data collected during the *boro* season in 1953-54 after 50 days of transplanting, which is not significant. The data are given in Table I.

TABLE I. TILLERS PER PLANT (AVERAGE OF 60 PLANTS)

Variety	1953–54				1954–55		
	Kharif Season	*Boro* Season			*Kharif* Season		*Boro* Season
	At harvest	50 days after transplanting (12-2-54)	78 days after transplanting (12-3-54)	At harvest	40 days after transplanting (20-8-54)	At harvest	At harvest
Assam I	10·6	8·1	15·4	14·0	17·5	15·5	13·9
Assam II	12·5	6·4	13·8	14·5	18·5	15·4	7·8
Assam IV	11·6	7·1	14·4	13·8	16·0	14·4	10·1
D.I. 3	11·0	6·3	18·1	16·0	16·4	11·2	10·8
D.I. 4	11·6	5·5	15·0	14·3	16·0	11·2	11·2
Kakuria	13·4	5·4	14·9	16·7	16·6	11·7	15·1
Chinsurah Boro I	14·7	8·1	21·6	21·4	19·7	18·0	17·7
Bhutmuri	13·3	7·0	19·8	22·1	18·2	14·8	14·3
Dhairal	9·1	5·7	13·8	15·1	10·8	10·3	10·3
Marichbutti	9·1	5·1	14·5	14·3	13·2	9·1	9·4
	C.D. at 1% level =3·1	Not significant	C.D. at 1% level =6·1	C.D. at 1% level =4·9	C.D. at 1% level =3·4	C.D. at 1% level =2·4	C.D. at 1% level =2·6

A marked difference in tillering was observed between the *kharif* and *boro* seasons when the tillers were counted at the early stage of growth, i.e., after 40 days of transplanting (20-8-54) during the *kharif* season, where a significant difference at one per cent level was recorded; no significant difference was recorded during the *boro* season when the tillers were counted after 50 days of transplanting (12-2-54). This shows the influence of temperature on tiller production; the low temperature in February (minimum 14·9° C) checks the tiller formation, but with a rise in temperature in March (12-3-54) a significant difference in tiller numbers at one per cent level is observed (Table IX). At harvest, there was no marked difference in tillers during the *kharif* and *boro* seasons, except in Chinsurah Boro I, Bhutmuri, Dhairal, Marichbutti and D. I. 3, where an appreciable increase was observed in 1953-54 during the *boro* season; in 1954-55, an increased number of tillers was produced in Assam II in the *kharif* season.

Height measurements were taken from the soil surface to the leaf tip of the longest shoot during the growing period; at harvest, they were taken up to the ear tip of the biggest shoot of the plant. The data were analysed statistically and found significant at one per cent level, except the data collected on February 12, 1954, which are

significant at five per cent level. The data with their critical difference are shown in Table II.

TABLE II. HEIGHT IN CM. (AVERAGE OF 60 PLANTS)

Variety	1953–54				1954–55		
	Kharif season	*Boro* season			*Kharif* season		*Boro* season
	At harvest	50 days after trans-planting (12-2-54)	78 days after trans-planting (12-3-54)	At harvest	40 days after trans-planting (20-8-54)	At harvest	At harvest
Assam I	127·7	42·6	84·9	103·0	105·1	143·3	115·9
Assam II	128·0	41·2	81·6	110·5	95·6	132·0	121·6
Assam IV	130·6	42·5	86·3	101·4	105·1	136·9	118·6
D.I. 3	142·2	39·7	69·2	97·4	94·6	143·0	113·8
D.I. 4	142·2	37·7	68·8	97·3	96·3	146·0	109·1
Kakuria	135·8	38·5	68·2	84·0	90·4	137·0	89·4
Chinsurah Boro I	119·0	42·2	61·2	88·8	91·0	117·6	99·9
Bhutmuri	118·1	36·9	55·7	84·5	86·1	120·5	94·1
Dhairal	115·6	36·6	58·5	74·8	82·9	124·3	83·2
Marichbutti	117·5	35·1	59·2	74·1	82·4	120·7	80·9
	C.D. at 1% level =8·4	C.D. at 5% level =5·2 Significant at 5% level	C.D. at 1% level =11·4	C.D. at 1% level =7·8	C.D. at 1% level =9·0	C.D. at 1% level =6·0	C.D. at 1% level =9·7

From the table it is seen that there is an appreciable increase in height in all the varieties from their initial stage of growth during the *kharif* season when compared with the height attained by the varieties during the *boro* season, and this increased height is maintained at harvest in both the years. This increased height is due to the rapid elongation of the shoot by the influence of the rainfall, temperature and humidity of the atmosphere during *kharif*, which have been found higher than in *boro* (Table IX). Khadilkar (1934) has reported that the culm-height of the rice plant varied directly with the July rainfall. In the early stages of vegetative growth of the varieties during the *boro* season (1953-54) it has been found that there is a significant difference in height between the varieties at five per cent level when measurements were taken after 50 days of transplanting (12-2-54), while no significant difference was observed in tillering during that period (minimum temperature 14·9° C), thus indicating different critical temperatures for tillering and growth in height, the critical temperature for tillering seems higher than the critical temperature for growth in height.

The data of ear emergence were noted by the same man each year in order to avoid the variations due to changes in personnel, when 50 per cent of plants had flowered, and are presented in Table III. The analysis of variance of the data is shown in Table IV. From the result of the analysis it is seen that the days of flowering of the varieties, season and year and their interactions are all significant at one per cent level.

TABLE III. DATES AND NUMBER OF DAYS REQUIRED TO FLOWER FROM SOWING (AVERAGE OF 6 REPLICATIONS)

Variety	1953–54				1954–55			
	Kharif season		*Boro* season		*Kharif* season		*Boro* season	
	Dates	Days	Dates	Days	Dates	Days	Dates	Days
Assam I	3–9–53 to 11–9–53	94·0	13–3–54 to 20–3–54	131·3	29–8–54 to 3–9–54	84·2	22–3–55 to 26–3–55	138·5
Assam II	3–9–53 to 11–9–53	95·3	13–3–54 to 22–3–54	132·2	1–9–54 to 4–9–54	85·3	22–3–55 to 29–3–55	140·8
Assam IV	1–9–53 to 11–9–53	90·0	10–3–54 to 15–3–54	128·7	29–8–54 to 3–9–54	83·8	17–3–55 to 22–3–55	133·7
D.I. 3	24–9–53 to 25–9–53	110·8	14–3–54 to 25–3–54	134·7	30–9–54 to 1–10–54	113·5	26–3–55 to 1–4–55	144·2
D.I. 4	24–9–53 to 25–9–53	110·3	16–3–54 to 23–3–54	134·0	30–9–54 to 2–10–54	113·7	28–3–55 to 31–3–55	144·8
Kakuria	5–10–53 to 7–10–53	122·6	15–3–54 to 27–3–54	135·2	3–10–54 to 7–10–54	118·2	22–3–55 to 28–3–55	140·3
Chinsurah Boro I	3–9–53 to 11–9–53	93·0	20–3–54 to 27–3–54	139·7	1–9–54 to 7–9–54	87·5	30–3–55 to 2–4–55	145·8
Bhutmuri	3–9–53 to 11–9–53	91·6	18–3–54 to 25–3–54	135·7	4–9–54 to 8–9–54	88·7	26–3–55 to 28–3–55	142·0
Dhairal	1–9–53 to 11–9–53	90·0	6–3–54 to 10–3–54	123·8	1–9–54 to 4–9–54	85·2	17–3–55 to 26–3–55	135·0
Marichbutti	1–9–53 to 11–9–53	90·6	7–3–54 to 12–3–54	124·3	2–9–54 to 4–9–54	85·8	16–3–55 to 26–3–55	134·7
	C.D. at 1% level = 4·8		C.D. at 1% level = 4·4		C.D. at 1% level = 2·0		C.D. at 1% level = 4·3	

A marked difference in days of flowering from sowing is noticed in the varieties when grown during the *boro* and *kharif* seasons; the flowering is much earlier in all the

TABLE IV. COMBINED ANALYSIS OF VARIANCE (FLOWERING IN DAYS)

Factor	Degrees of freedom	Sum of square	Variance	Ratio
Total	239	1,17,075·98		
Varieties	9	12,977·82	1,441·98	222·53**
Seasons	1	92,433·75	92,433·75	14,264·46**
Year	1	212·82	212·82	32·84**
Season × variety	9	6,932·75	770·31	118·87**
Season × year	1	2,269·35	2,269·35	350·21**
Year × variety	9	449·18	49·91	7·70**
Variety × season × year	9	232·32	25·81	3·98**
Blocks (within year, within season)	20	401·07	20·05	
Error	180	1,166·92	6·48	

**Significant at 1 per cent level.

varieties during *kharif*. Kakuria, D.I. 3 and D.I. 4 took significantly much longer to flower compared with the rest, in both the years during *kharif*, while the other varieties flowered earlier, by the first half of September. During the *boro* season, all the varieties, irrespective of *aus* or *boro*, flowered more or less during the second half of March. The results of the two years' observation show that the varieties start flowering in September during *kharif* and in March during *boro* when the day-length is over 12 hours (Table IX), except in Kakuria which flowers in the first week of October during *kharif*. Thus it appears that the day-length is mainly responsible for the flowering of these *aus* and *boro* varieties as they are found almost fixed for a particular day-length, i.e., above 12 hours. In winter (*aman*) paddy, flower initiation takes place when the day-length is less than 12 hours (Sircar, 1948; Sircar and Ghosh, 1954).

Measurements of the length and the maximum breadth of the flag leaf were taken at harvest from the longest shoot. The data were analysed statistically and found to be significant at one per cent level. The data are given in Table V.

The results show that in both the years the length and breadth of the flag leaf were greater in the *kharif* than in *boro* season, the increase being greater in the case of the length of the flag. Similar results have been obtained in the case of plant growth in height (Table II). This increased growth in length and breadth of the flag leaf during *kharif* is caused by the influence of high temperature and humidity of the atmosphere and heavy rainfall (Table IX).

The grain and straw yield data collected in two years during the *kharif* and *boro* seasons in 1953-54 and 1954-55 were analysed statistically and found to be significant at one per cent level. The mean yields of grain and straw with their critical difference and their combined analysis of variance are given in Tables VI and VII.

TABLE V. LENGTH AND BREADTH OF THE FLAG LEAF IN CM. (AVERAGE OF 60 PLANTS)

Variety	1953–54				1954–55			
	Kharif Season		*Boro* Season		*Kharif* Season		*Boro* Season	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
Assam I	36·31	1·19	25·96	1·15	43·19	1·21	26·65	1·09
Assam II	37·24	1·22	28·18	1·17	42·28	1·12	29·71	1·31
Assam IV	40·19	1·24	26·46	1·15	41·73	1·17	28·15	1·10
D.I. 3	33·94	1·33	19·93	1·16	31·58	1·44	21·90	1·21
D.I. 4	35·39	1·30	18·78	1·15	33·20	1·44	22·46	1·21
Kakuria	45·83	1·22	21·25	1·16	38·09	1·25	21·88	1·14
Chinsurah Boro I	36·03	1·13	21·66	0·92	40·27	1·07	23·90	0·93
Bhutmuri	32·73	1·14	19·36	1·07	33·89	1·15	20·00	1·03
Dhairal	31·08	1·40	21·26	1·26	33·71	1·50	22·37	1·22
Marichbutti	33·93	1·39	19·51	1·22	34·82	1·48	20·33	1·14
	C.D. at 1% level =4·5	C.D. at 1% level =0·13	C.D. at 1% level =3·50	C.D. at 1% level =0·11	C.D. at 1% level =4·84	C.D. at 1% level =0·12	C.D. at 1% level =3·48	C.D. at 1% level =0·10

TABLE VI. GRAIN AND STRAW YIELD IN SEERS* (AVERAGE OF 6 REPLICATIONS)

Variety	1953–54				1954–55			
	Kharif season		*Boro* season		*Kharif* season		*Boro* season	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Assam I	3·78	13·92	3·83	18·92	5·50	25·67	4·02	10·17
Assam II	4·64	16·00	4·50	9·17	2·99	26·65	2·71	10·44
Assam IV	3·92	15·42	4·67	16·42	5·26	22·27	3·29	9·71
D.I. 3	3·25	15·50	7·75	10·00	3·15	42·44	6·04	12·37
D.I. 4	2·80	15·00	7·50	10·92	2·31	50·46	5·56	11·77
Kakuria	2·98	30·17	5·08	9·17	3·44	44·91	3·54	8·90
Chinsurah Boro I	6·50	16·00	8·08	13·92	7·69	25·19	7·73	19·02
Bhutmuri	4·39	13·92	6·92	12·75	7·53	36·20	6·67	11·21
Dhairal	4·28	13·00	3·83	7·00	7·49	31·10	2·27	5·44
Marichbutti	6·34	12·08	4·17	7·50	6·88	22·11	3·21	6·46
	C.D. at 1% level =1·68	C.D. at 1% level =3·61	C.D. at 1% level =2·44	C.D. at 1% level =5·73	C.D. at 1% level =1·30	C.D. at 1% level =6·66	C.D. at 1% level =2·50	C.D. at 1% level =5·99

*1 seer = 2·057 lb.

TABLE VII. COMBINED ANALYSIS OF VARIANCE (GRAIN AND STRAW YIELD)

Factor	Degrees of freedom	Variance		Ratio	
		Grain	Straw	Grain	Straw
Varieties	9	34·147	292·424	19·749**	22·412**
Seasons	1	5·856	10,676·269	3·387	818·531**
Year	1	0·566	3,636·218	0·327	278·782**
Season × variety	9	32·367	361·216	18·720**	27·693**
Season × year	1	64·118	4,661·548	37·084**	357·392**
Year × variety	9	6·232	178·343	3·604**	13·673**
Variety × season × year	9	2·446	122·914	1·414	9·423**
Blocks (within year, within Season)	20	8·213	31·941		
Error	180	1·729	13·043		

**Significant at 1% level.

The combined analysis of variance of grain yield data shows that the season and year have no effect on the grain yield, while the interactions between the season and variety, year and variety, and season and year are all highly significant at one per cent level. In the case of straw, variety, season and year and their interactions are all significant at one per cent level.

A further analysis of the grain yield data has been done in detail, splitting the varieties with a view to finding out whether the effect of season and grain yield of the varieties is statistically significant. From the result of the analysis given in Table VIII, it is seen that the interactions between *aus* and season and *boro* and season are highly significant, indicating thereby that there exists a significant effect of the season on the grain yield of different varieties of *aus* and *boro* paddy at one per cent level.

Among the varieties, the highest yield of grain was recorded by Chinsurah Boro I in both the years during the *kharif* and *boro* seasons, and the yield was almost same in both the seasons, indicating thereby that although this variety belongs to *boro* it can safely be grown during *kharif* as *aus* in spite of opposite weather conditions in the two seasons. During the *boro* season, there is bright sunshine—the average daily sunshine being above nine hours—less rainfall, low temperature and humidity, while the weather conditions during the *kharif* season, during the growth period of paddy is mostly cloudy—the daily sunshine being nearly five to six hours—with heavy rainfall and high temperature and humidity (Table IX). Among the *aus* varieties, Bhutmuri performed well during the *boro* season in both the years, giving 6·92 and 6·67 seers of grain per plot in 1953-54 and 1954-55 respectively, which are statistically on a par with Chinsurah Boro I. From this it can be concluded that this variety can also be grown both during *kharif* and *boro*. D.I. 4 gave the lowest yield in both the years during the *kharif* season, but the difference in yield with those of D.I. 3 and Kakuria

TABLE VIII. DETAILED ANALYSIS OF VARIANCE OF GRAIN YIELD

Factor	Degrees of freedom	Sum of square	Variance	Ratio
Aus vs. *Boro*	1	17·9370	17·9370	10·3742**
Aus	2	44·8580	22·4290	12·9722**
Boro	6	244·5240	40·7540	23·5708**
Varieties	9	307·3190	34·1465	19·7492**
Season	1	5·8562	5·8562	3·3870
Year	1	0·5655	0·5655	0·3270
(*Aus* vs. *Boro*) × season	1	97·9931	97·9931	56·6761**
Aus × season	2	55·0679	27·5339	15·9247**
Boro × season	6	138·2428	23·0404	13·3258**
Variety × season	9	291·3039	32·3671	18·7201**
(*Aus* vs. *Boro*) × year	1	15·7840	15·7840	9·1289**
Aus × year	2	8·3445	4·1722	2·4130
Boro × year	6	31·9602	5·3267	3·0807**
Variety × year	9	56·0889	6·2321	3·6044**
Season × year	1	64·1184	64·1184	37·0840**
Variety × season × year	9	22·0164	2·4462	1·4148
Blocks (Within year, within season)	20	164·2675	8·2134	
Error	180	311·2256	1·7290	

**Significant at 1% level.

was not significant in 1953-54; but in 1954-55 there was a significant difference between Kakuria and D.I. 4, but no difference between D.I. 3 and D.I. 4. From a scrutiny of the two years' results, it appears that these three *boro* varieties— D.I. 3, D.I. 4 and Kakuria—are not at all suitable for cultivation during the *kharif* season, while among the *aus* varieties, Dhairal and Marichbutti are found unsuitable during the *boro* season as their yields are very poor. D.I. 3, D.I. 4 and Kakuria may be called as true *boro* and Dhairal and Marichbutti true *aus*. Regarding the Assam varieties, no definite conclusion can be drawn at present as they gave somewhat erratic results.

The result of the straw yield seems somewhat erratic, most probably due to the straw not being dried to the same extent in the sun in each season. In 1953-54 during *kharif*, Kakuria gave the highest yield and was significantly superior to the rest, while in 1954-55, D.I. 4 gave the highest yield and was significantly superior to the others, followed closely by Kakuria and D.I. 3 in 1953-54 during the *boro* season. Assam I gave the highest yield and was statistically on a par with Assam IV, next being

Chinsurah Boro I, while in 1954-55, Chinsurah Boro I gave the highest yield and was significantly superior to the rest. The minimum yield was obtained in Dhairal during the *boro* season in both the years.

TABLE IX. METEOROLOGICAL DATA (1953-54 AND 1954-55)

Season	Month	Average max. temperature °C	Average min. temperature °C	Relative humidity (%) at 14·00 hr.	Total rainfall in mm.	Day-length in hours: Maximum	Day-length in hours: Minimum	Average hours of bright sunshine
	June, 1953	33·9	26·0	71	276·1	13·6	13·5	5·6
	June, 1954	32·2	25·6	78	298·7			5·5
	July, 1953	31·4	26·2	81	315·0	13·6	13·2	4·7
	July, 1954	31·7	26·4	78	184·7			5·6
Kharif	August, 1953	31·2	26·1	78	199·4	13·2	12·6	4·4
(wet)	August, 1954	31·7	26·1	79	129·8			4·7
	September, 1953	31·0	25·9	82	250·2	12·6	12·0	5·2
	September, 1954	31·4	25·9	78	292·1			6·4
	December, 1953	27·4	12·1	41	0·0	10·8	10·7	9·1
	December, 1954	26·4	10·7	45	40·4			8·6
	January, 1954	24·9	8·7	38	19·6	11·1	10·8	9·1
	January, 1955	25·6	9·7	39	0·0			9·1
Boro	February, 1954	31·2	14·9	31	6·1	11·5	11·1	9·9
(dry)	February, 1955	29·3	10·7	31	0·0			10·0
	March, 1954	35·1	18·8	26	0·0	12·4	11·7	10·1
	March, 1955	35·5	19·8	27	23·6			9·0

SUMMARY

During the initial stages of growth of the plants, a significant difference in the tillers among the varieties is noticed in the *kharif* (wet) and *boro* (dry) seasons. This difference in tiller formation seems to be due to the difference in temperatures of the two seasons. The low temperature in January and February during the *boro* season checks the rate of tiller formation, while the higher temperature in July and August during *kharif* increases the rate. It is interesting to note that during the growing period in the *boro* season, when low temperature checks the rate of tiller formation, the plant growth in height continues, thereby indicating that the critical temperature for tillering is higher than the critical temperature for growth in height.

The height of the plant and the length and breadth of the flag leaf were found to be related with the rainfall, temperature and humidity of the atmosphere, because greater plant height and flag leaf length and breadth were recorded during the *kharif* season in both the years, when high temperature and high percentage of relative humidity prevailed and heavy rainfall received.

The ear emergence begins, irrespective of *boro* and *aus* varieties, when the day-length is over 12 hours, thus indicating that the day-length is responsible for the

flowering. As the flowering of these *aus* and *boro* varieties has taken place when the day-length is over 12 hours, they may be called "long-day plants".

In spite of different weather conditions during the *boro* and *kharif* seasons, Chinsurah Boro I and Bhutmuri, though belonging to *boro* and *aus* group, respectively, behave perfectly well in both the seasons in respect of their grain yield, while the other *boro* varieties—D.I. 3, D.I. 4 and Kakuria—are very sensitive to climatic conditions as indicated by their very poor grain yield during the *kharif* season when they contributed mostly towards straw. Similarly, the other two *aus* varieties, Dhairal and Marichbutti, are found unsuitable for cultivation during the *boro* season, as their performance was not satisfactory. D.I. 3, D.I. 4 and Kakuria may be called as true *boro*, while Dhairal and Marichbutti as true *aus*.

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EFFECTS OF SOAKING SEEDS IN NUTRIENT SALTS

I. ABSORPTION OF ZINC BY COTTON SEEDS FROM ZINC SULPHATE SOLUTION AND ITS INFLUENCE ON GROWTH AND YIELD

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Soaking of seeds in nutrient solutions, prior to sowing, has been attempted as a means of increasing crop yields by several workers. Gusev (1940) and Narayanan and Gopalkrishnan (1949) have reported increased yields as a result of soaking seeds in nutrient solutions. While trying to supply boron as a trace element requirement to cotton by soaking in boric acid, Novikov and Sodovskaja (1939) also obtained an increase in the yield. Roberts (1948), on the basis of a preliminary experiment on oats grown on manganese deficient soil, suggested that a large part of their manganese requirement, at least in the early stages of growth, can be provided by soaking.

A study on soaking seeds of some crops in micronutrient solutions was undertaken in the Division of Botany, Indian Agricultural Research Institute, New Delhi, with a view to estimating quantitatively the amount of salt absorbed by the testa and embryo of seeds from the soaking solution. It was also studied whether the amount of salt thus absorbed by the seeds would suffice, as a trace element requirement, for the entire life-cycle of the plant under water culture in the nutrient solution deficient in the salt used for soaking. In the present paper, it is proposed to incorporate the results of chemical estimations of zinc ions absorbed by cotton seeds from zinc sulphate solution and their performance under water culture deficient in zinc and under field conditions.

MATERIAL AND METHODS

Seeds of cotton (var. 216F) were soaked for a period of 24 hours in various concentrations of zinc sulphate solution (M/100 to M/1,000) in a ratio of 1:10 between the seed mass and solution volume at room temperature (during the month of June, 1958). The seeds, before soaking, were sterilized with one per cent mercuric chloride solution; after soaking, they were rinsed with distilled water. These seeds were then germinated on moist filter-paper in glass petri-dishes, and the seedlings were separated from the testa when three to four days old. The zinc contents of the seedlings and testa were estimated separately by polarograph, adopting the J. F. Reed and R. W. Cumming's method. The amount of zinc left in the soaking solution after removing and washing the seeds was also estimated just to determine the total quantity of zinc absorbed by the seeds from the solution. The effect of different concentrations of the zinc sulphate solution on the germinating capacity of the seeds was also observed. The seeds under control were soaked in distilled water only.

Water culture experiment

In the water culture experiment, the seedlings raised from the seeds soaked in an M/400 concentration of zinc sulphate solution, were transferred to Pyrex beakers (two-litre capacity) containing a nutrient solution (Hoagland) from which zinc was withheld. Under control, the plants were raised from the seeds soaked in distilled water; it was run in two separate series. The controls were maintained with and without zinc. Each treatment contained four plants. The salts used for soaking were laboratory reagents and those used in the nutrient solution were purified by dithizone. Pyrex beakers of two-litre capacity were used, and the water distilled from a Pyrex glass still, and tested by dithizone for its freedom from all the metals, was used. The seedlings were set up in the water culture on 2-9-1958 and harvested on 1-11-58 after recording the plant height, number of leaves and fresh weights of different parts. The zinc contents of the leaves and stem were determined separately.

Field Experiment

Delinted seeds of the variety 216F of cotton were soaked separately in solutions of zinc sulphate (250 ppm. concentration of zinc) ferrous sulphate (250 ppm. concentration of iron) and boric acid (250 ppm. concentration of boron), with a ratio of 1:10 between the seed mass and the volume of each solution, for 24 hours, at room temperature (on 1-6-59). These seeds, after washing with water, were sown in the field on 2nd June, 1959, adopting a simple randomized layout with four replications. Under control, the seeds were soaked in water only, and a second control using unsoaked seeds was also included. The spacing, seed-rate and other cultural operations were all uniform for all the treatments. Five plants were tagged in each bed for morphological observations, and thus the mean values were based on observations on 20 plants. Ammonium sulphate at the rate of 20 lb. N per acre was also applied to all the treatments, 50 days after sowing. It may be pointed out here that in the field experiment, besides zinc, two other salts, viz., iron and boron, were also included, but their effects will not be discussed in this paper.

RESULTS

Zinc content

It will be seen from the data in Table I that the zinc contents of the seedlings and testa from seeds which were soaked in various concentrations of zinc solution (M/100

TABLE I. ABSORPTION OF ZINC FROM 150 CC. OF ZINC SULPHATE SOLUTION IN 24 HOURS AT ROOM TEMPERATURE BY 15 GM. OF COTTON SEEDS, TESTA AND SEEDLINGS

(Date 16-6-1958)

Concentration of zinc sulphate solution	Quantity of zinc absorbed in mg.	Zinc as ppm. of dry weight		Percentage germination
		Seedlings	Testa	
Control (water-soaked)	Nil	40·0	67·0	72
M/100	64·5	700·0	3818	71
M/200	36·7	535·0	3408	72
M/400	21·9	395·0	2188	72
M/600	14·5	210·0	1888	70
M/800	10·8	124·0	1265	76
M/1,000	8·7	104·0	935	73

to M/1,000) were found to be much higher than that of the control. The concentration of zinc absorbed both in the seedlings and testa, decreased with the decrease in the concentration of the soaking solution. The germinating capacity of the seeds was not affected adversely by any of the concentrations used for soaking.'

Water culture experiment: From day-to-day observations on the plants during the early stage of growth, it was observed that the plants which were raised from the seeds soaked in the zinc solution were also as healthy as those under the control with zinc (+Zn), whereas the plants under the other control, where the nutrient solution was deficient in zinc (—Zn), were stunted in growth from an early stage also exhibiting typical symptoms of zinc deficiency on their leaves within about three weeks. It was observed later, when the plants were about six weeks old, that the growth of the plants from zinc-soaked seeds also fell off and the symptoms of zinc deficiency appeared on the leaves.

TABLE II. MEAN STEM HEIGHT, NUMBER OF LEAVES, FRESH WEIGHTS AND ZINC CONTENT

Treatment	No. of leaves per plant	Stem height in cm.	Fresh weights in gm.			Zinc content on dry weight basis (in ppm.)	
			Green leaves	Stem	Floral buds	Leaves	Stem
Zinc soaked	16	40·4	39·0	45·4	..	13·0	13·0
Control (—Zn)	15	32·0	28·4	30·5	..	11·5	10·5
Control (+Zn)	17	64·1	83·3	98·0	60·0	17·5	16·5

From the data on plant height, leaf number and fresh weights (Table II); it would appear that there were very marked differences in the heights of plants under the three treatments, the mean values for single plant under zinc-soaked and minus zinc treatments, being 40·4 cm. and 32·0 cm., respectively, as against 64·1 cm. of the plants under the normal control (+Zn). Similar differences were observed in regard to leaf number per plant, fresh weights of stem, leaves, and floral buds and also in regard to the zinc content of the leaves and stem.

Field Experiment: The data on the number of primary branches, number of green bolls and matured bolls per plant and yield of seed cotton per plant as well as per acre are given in Table III. It will be seen from these data that the yields

TABLE III. MEAN NUMBER OF PRIMARY BRANCHES, BOLLS (GREEN AND MATURE) AND YIELD OF SEED COTTON PER PLANT AND PER ACRE

Treatment	No. of primary branches per plant	No. of green bolls per plant	No. of matured bolls per plant	Yield of seed-cotton per plant (in gm.)	Yield of seed-cotton per acre in lb.
Control (unsoaked)	22·3	28·3	25·4	66·3	709
Control (water-soaked)	21·5	25·9	22·6	61·1	697
Zinc sulphate	21·7	31·2	21·1	52·2	664
Boron (Boric acid)	20·4	27·6	25·9	68·3	716
Iron (Ferrous sulphate)	22·9	28·5	25·2	66·3	750
Statistical significance	Not significant	Not significant	Not significant	Not significant	Not significant

per plant and per acre of seed cotton under zinc sulphate treatment were more or less equal to those under the two controls, i.e., under water-soaked and unsoaked treatments. No differences were also observed between the treatments in regard to number of branches and number of green bolls and matured bolls per plant.

CONCLUSION

The zinc contents of the seedlings and the testa of cotton were increased by soaking the seeds in zinc sulphate solution. The major proportion of the zinc absorbed by the seeds from the zinc solution was retained by the testa. The work of Brown (1907, 1909), Collins (1918), Brown (1932) and Tharps (1936), on the characters of seed-coat and the layers forming the thin skin surrounding the endosperm and embryo of cereals, also suggests that it would form a barrier to the entry of any chemical in which the seeds are soaked. Kotowski (1927), found that the nature of the seed-covering limited the intake of salts. It was also noted that the quantity of zinc absorbed decreased with the decrease in the concentration of the soaking solution.

It was seen that the plants from the seeds soaked in zinc sulphate solution showed better growth (height, leaf number and fresh weights of leaves, stem and flowers) than those soaked in distilled water only under nutrient solution deficient in zinc; the former were, however, inferior in growth to those from controlled seeds grown in a culture solution with zinc. It may be concluded that the extra amount of zinc which was absorbed by the seeds from the zinc sulphate solution during the soaking helped the plants in making some growth, but was not enough to fulfil the requirement of plant for zinc for the entire life-cycle if it was raised in a nutrient solution deficient in zinc. These results are in agreement with those of Roberts (1948) who suggested in the case of oats that a large part of the manganese requirement, at least in early stages of growth, could be provided by soaking; any further requirement could be made good by spraying.

The results of the field trial indicated that the treatment of soaking cotton seeds in zinc sulphate solution, before sowing, had no influence on either single plant yield or yield per acre of seed cotton. In this connection it may, however, be pointed out that the soil in which the trial was conducted, was not known to be deficient in zinc.

SUMMARY

The amount of zinc absorbed by seeds of cotton (variety 216 F) from zinc sulphate solution of various concentrations, was determined separately in the testa and seedlings by the polarographic method. It was observed that the zinc contents of both testa and seedlings increased over that of control (water-soaked). The concentration of zinc in the testa was found to be higher than that of the seedlings and the concentration of zinc contents both in the seedlings and testa decreased with the decrease in the concentration of the soaking solution. The germination of the seeds was not adversely affected by soaking.

Under water culture deficient in zinc, plants from zinc-soaked seeds made better growth than those from unsoaked seeds for some time and developed symptoms

of zinc deficiency later, thus indicating that the zinc absorbed by the seeds was not sufficient to meet the zinc requirement for the entire life-cycle.

The treatment of soaking seeds of cotton in zinc sulphate solution had no influence on the yield of seed cotton under field conditions.

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STUDIES ON THE CUMULATIVE EFFECT OF INORGANIC FERTILIZERS, ORGANIC MANURES AND THEIR COMBINATION ON THE YIELD AND CHEMICAL COMPOSITION OF MAIZE IN CALCAREOUS SOIL

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A POPULAR belief exists in the realm of practical agriculture that a frequent use of chemical fertilizers affect cereal crops to an appreciable extent, both in yield and in their chemical composition. It was observed by early workers that the maize yield decreased on plots which continuously received fertilizers whereas on plots receiving compost no such deterioration was noticed (Urano and Tanaka, 1954). In the permanent manurial experiment at Pusa (Bihar), F.Y.M. at the rate of 30 lb. N per acre gave the highest yield of maize (Menon and Bose, 1937) while in the new manurial series, rape-cake followed by F.Y.M. produced the significantly highest yield of the same crop (Sen and Kavitkar, 1956).

Conflicting views have, however, been recorded in literature regarding the effect of climate on the yield and chemical composition of maize. As for example, no material difference in the composition of maize due to variation of soils and climates was observed by Hunt (1905); Baker *et al.* (1940) observed a low protein value under a mild-humid climate, and Wolfe (1925) reported an increase in the yield of maize with an increase in the rainfall up to a certain limit. That the nitrogen content in the maize grain declines in a cold, wet year and rises in a hot year has also been reported by Soubies and Gadet (1953).

In view of these observations, the present study with maize was undertaken to find out how the yield and chemical composition of this crop changed with different treatments under intensive cultivation, and also to assess the depth of the climatological effect, if any. In the long-term experiments of the early workers, the effects of fertilizers and manures were probably not fully reflected since grains from the different plots were mixed up every year. In order to minimize this error, attempts were made in the present investigation to carefully preserve separately the seeds from separate plots and to sow them in the respective plots in each succeeding year.

Fertilizers and manures were applied every year and during *rabi* a wheat crop was taken from the same plots. The following standard materials were used for manuring:

(1) ammonium sulphate as the inorganic nitrogen source;
(2) superphosphate as the P_2O_5 source; and
(3) F.Y.M. as the nitrogen source in organic form.

The area of each plot was 1/1,000 acre and the layout was on randomized block design having four replications. The treatments were as follows:

Treatments	*Symbol*
(1) F.Y.M. @ 80 lb. N per acre	A
(2) $(NH_4)_2SO_4$ @ 40 lb. N—Superphos. @ 80 lb. P_2O_5 per acre	B
(3) F.Y.M. @ 40 lb. N—$(NH_4)_2SO_4$ @ 20 lb. N—Superphos. @ 80 lb. P_2O_5 per acre	C

The F.Y.M. was applied to the plots every year one month ahead of sowing, while the rest of the fertilizers were applied at the time of sowing. The crop variety used was maize yellow having the following composition:

Nitrogen	=1·59%
P_2O_5	=0·84%
K_2O	=0·45%

Thirty-two plants were raised in each plot every year.

The soil is sandy loam in texture, highly calcareous, containing 36 per cent $CaCo_3$, and has the following other compositions:

*p*H	8·0
Total N	0·039 %
Hcl extraced P_2O_5	0·15%
Available P_2O_5	0·002%
K_2O	0·36%
Fe_2O_3	2·11%
Org. carbon	0·25%
Exch. Ca	2·10 me%

MATERIAL AND METHODS

The present work was carried out at the Botanical Substation, Pusa, Bihar, which falls in a zone of subtropical humid climate with an annual rainfall of about 50 inches.

Representative samples of maize grain were collected from the plots separately and ground to a uniform fineness. A small uniform portion of each sample was then taken for analysis. The soil samples were collected from the plots every year after harvest.

The nitrogen in the plant material and in the soil was estimated by the official Kjeldahl method, while the phosphoric acid in the maize was determined from solutions obtained by a wet digestion of the materials with HNO_3 and perchloric acid.

The *p*H of the soil was determined by the Cambridge *p*H meter and the available P_2O_5 by Das's method (Das, 1932) using K_2CO_3 extract. The org. C was estimated by the Walkly and Black's (Piper, 1950) method while exch. Ca was determined by the Nacl extraction method of Hissink as described by Piper (Piper, 1950).

RESULTS AND DISCUSSION

Effect of different treatments in the yield of maize

The experiment was conducted for six years, but as the crop was damaged by excessive rain in 1955 only five years' data have been assessed for yield and nitrogen and phosphoric acid contents. In Table I, the average yield of maize grain for each year and the cumulative effect per plot are given against each treatment.

TABLE I. TREATMENT EFFECTS IN INDIVIDUAL YEARS ON YIELD OF MAIZE (EXPRESSED IN LB./PLOT)

Year	Tr. A	Tr. B	Tr. C	S.E.	C.D. at 1%	C.D. at 5%	Remarks
1954	2·09	2·22	1·28				Not sig.
1956	1·22	0·72	1·16				,,
1957	1·55	0·65	1·11				,,
1958	1·20	0·61	1·03				,,
1959	2·79	0·60	1·41	±0·274	1·44	0·95	Highly sig.
Cumulative effect	1·77	0·96	1·20	±0·1053	0·409	0·304	Highly sig. A. C. B.

It is seen that in the fifth year of the experiment in 1959, a highly significant difference between the treatments has been obtained, the treatment F.Y.M. producing the maximum yield both at one per cent and five per cent levels. The trend of the data actually indicated that the crop responded more to organic manure and the least to chemical fertilizers every year, except the first year of the experiment. Besides, the cumulative effect of the experiment has also recorded a highly significant difference in yield between the treatments, F.Y.M. again producing the best effect. Although the mean yield of maize recorded a rapid fall under the NP treatment, the data revealed a comparatively steady decrease in yield in the presence of F.Y.M. till 1958, while in 1959 the yield under F.Y.M. and the combined treatment registered a sharp rise again.

Effect of different treatments on the nitrogen and phosphoric acid contents of grains

The average nitrogen and phosphoric acid contents are represented in Table II. It will be seen that the nitrogen content in grain showed a higher value under the NP treatment in the first year of the experiment, thereafter decreasing at a faster pace than the F.Y.M. treatment. Under the combined treatment also, a considerable decrease has been noticed. It is, however, important to note that no statistically significant difference in the nitrogen content has been observed between the treatments in any year so far. Generally speaking, therefore, the nitrogen content in the grain appears to be less affected by the different manurial treatments although it deteriorated under all the three treatments from the initial value.

Unlike the nitrogen value, the phosphoric acid content in the grain exhibited a significant difference for two years, and in both the years the NP treatment displayed the minimum percentage. Generally speaking, however, a rise and fall trend in the P_2O_5 data does not permit to attribute wholly any effect to a particular treatment although it is evident from Table III that under all the three treatments the value of P_2O_5 has significantly decreased from the initial value of phosphoric acid in the grain. In other words, it may be concluded that a general deterioration of phosphoric acid

in the grain took place by the continuous use of either organic manure or inorganic fertilizers which is rather prominent in the latter case.

TABLE II. TREATMENT EFFECT IN INDIVIDUAL YEARS ON CHEMICAL COMPOSITION OF MAIZE

Year	% Nitrogen content in grain			Remarks
	Tr. A	Tr. B	Tr. C	
1954	1·51	1·60	1·59	Not significant
1956	1·27	1·09	1·14	,,
1957	1·54	1·56	1·56	,,
1958	1·54	1·41	1·39	,,
1959	1·42	1·22	1·39	,,

Year	% P_2O_5 content in grain					Remarks
	Tr. A	Tr. B	Tr. C	S.E.	C.D. at 5%	
1954	0·72	0·74	0·73	..	..	Not significant
1956	0·50	0·45	0·54	± ·02	0·07	C, A, B
1957	0·49	0·52	0·49	..	..	Not significant
1958	0·62	0·55	0·56	± ·022	0·05	A, C, B
1959	0·57	0·47	0·53	..	..	Not significant

TABLE III. COMBINED ANALYSIS OF P_2O_5 IN GRAIN

Year	Tr. A	Tr. B	Tr. C	Mean	S.E. year (mean)	C.D. 5%	C.D. 1%
1954	0·72	0·74	0·73	0·73	±·0145	·041	·056
1956	0·50	0·45	0·54	0·50	At=5%	1954, '58,	'59, '56, '57
1957	0·49	0·52	0·49	0·49			
1958	0·62	0·55	0·56	0·58	At=1%	1954, '58,	'59, '56, '57
1959	0·57	0·47	0·53	0·52			

Remarks: Year to year differences are highly significant.

Effect of weather condition upon yield of maize and its nitrogen and phosphoric acid contents

The data in Table IV show that unlike Wolfe's observation the yield of maize did not increase with the increase in rainfall in any of the treatments. Under F.Y.M., the yield varied inversely with the rainfall, and similar is the trend under the combined

treatment also except in the year 1957 when it remained almost unchanged. In the NP treatment, however, the yield has been found to decrease progressively irrespective of rainfall.

In conformity with the observations of earlier workers, it has been observed that the grain nitrogen in the maize varied inversely with the rainfall. This phenomenon, however, was true for four years, while in 1959, the nitrogen in the grain decreased with a decrease in the rainfall. The reason for the low nitrogen content in the grain in a wet year, though not fully understood, is ascribed to a lower uptake of nitrogen due to the possible leaching out of No_3 from the root zone and less transpiration under a wet, cool weather.

TABLE IV. RAINFALL, YIELD, AND N, P, CONTENTS OF MAIZE GRAIN UNDER INDIVIDUAL TREATMENTS

Year	Rainfall during *Kharif* (inches)	Tr. A.			Tr. B.			Tr. C.		
		Yield	N%	%P_2O_5	Yield	N%	%P_2O_5	Yield	N%	% P_2O_5
1954	43·43	2·09	1·51	0·72	2·22	1·60	0·74	1·28	1·59	0·73
1956	45·56	1·22	1·27	0·50	0·72	1·09	0·45	1·16	1·14	0·54
1957	32·96	1·55	1·54	0·49	0·65	1·56	0·52	1·11	1·56	0·49
1958	41·20	1·20	1·54	0·62	0·61	1·41	0·55	1·03	1·39	0·56
1959	18·66	2·79	1·42	0·57	0·60	1·22	0·47	1·41	1·39	0·53

The phosphoric acid in the grain on the other hand did not display any relation either to dry or wet, cool weather under any of the three treatments.

Effect of the treatments on soil fertility status

The data on soil (Table V) revealed an augmented value for N, available P_2O_5 and org. C under the F.Y.M. treatment, both alone and in combination, while an almost depleting action on N and C in the soil has been demonstrated by a continuous application of chemical fertilizers alone. The relatively higher value for the available P_2O_5 under F.Y.M. and the combined treatment may be accounted for by the fact that most of the phosphoric acid in F.Y.M. exists in an inorganic and available form and that the organic phosphorus present is fairly quickly mineralized in neutral soils (Ghani, 1941).

The noticeable decrease in the two primary soil constituents, N and C, may be the reason for a rapid fall of maize yield under the NP treatment as compared to the F.Y.M. and combined treatments. On the other hand, since organic matter maintains a steady supply of plant nutrients till the later stage of plant growth, it produces a higher yield of maize and a higher level of soil fertility is obtained. It can, however, be accomplished after accumulation of organic matter in the soil. This has actually been corroborated by the fact that in the first year of the experiment the NP treatment produced a higher yield than either F.Y.M. or the combined treatment.

TABLE V. DATA REPRESENTING SOIL ANALYSIS AFTER HARVEST UNDER INDIVIDUAL TREATMENT

Year	Tr. A.					Tr. B.					Tr. C.				
	*p*H	N%	Avail. P_2O_5%	C%	C/N	*p*H	N%	Avail. P_2O_5%	C%	C/N	*p*H	N%	Avail. P_2O_5%	C%	C/N
Initial	8·0	·039	·0022	·26	6·6	8·0	·039	·0022	·26	6·6	8·0	·039	·0022	·26	6·6
1954	..	·048	·0036	·28	5·8	..	·040	·0028	·26	6·5	..	·042	·0032	·28	6·6
1956	..	·052	·0033	·39	7·5	..	·035	·0026	·25	7·1	..	·046	·0030	·34	7·3
1957	..	·041	·0045	·30	7·3	..	·029	·0035	·22	7·5	..	·042	·0043	·32	7·6
1958	..	·056	·0065	·40	7·1	..	·033	·0054	·20	6·0	..	·043	·0058	·30	6·9
1959	7·81	·069	·0086	·59	8·5	8·3	·028	·0035	·20	7·1	8·01	·059	·009	·41	6·9

SUMMARY

An experiment to study the effect of NP, F.Y.M. and their combination on the yield and chemical composition of maize, using the same seed for the same plot in each succeeding year, was carried out.

The F.Y.M. produced the significantly highest yield in 1959 and also the maximum yield in all the years, except the first year of the experiment. It also displayed the significantly highest cumulative effect on the maize yield.

The maize yield decreased continuously and rapidly under the NP treatment only.

The nitrogen content in the grain did not show any significant difference as a result of the different treatments. The deterioration of the nitrogen content in the grain has, however, been observed under all the treatments though to a lesser degree under the F.Y.M.

The P_2O_5 in the grain was significantly the highest under the F.Y.M. in one year only. A general deterioration of this element in the grain took place under all the treatments.

The wetness and dryness of weather have got much influence on the maize yield, and the grain nitrogen is also affected to an appreciable extent. The year of heavy rainfall produced less yield.

The N and org. C in the soil diminished considerably in the NP-treated plots. This diminishing effect has been reflected by the maize yield which recorded a rapid fall under this treatment.

In general, it may be concluded that the yield of maize is adversely affected by a continuous application of chemical fertilizers alone. The nitrogen and phosphoric acid contents in the grain also deteriorate under intensive cultivation of maize. Both the yield and grain nitrogen are found to be markedly influenced by the wetness and dryness of the weather as well.

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INHERITANCE STUDIES IN WHEAT

XI. INHERITANCE OF SEEDLING REACTION TO PHYSIOLOGIC RACE 75 AND BIOTYPE 42B OF *PUCCINIA GRAMINIS TRITICI* ERIKSS AND HENN. IN SOME INTERVARIETAL CROSSES OF *TRITICUM AESTIVUM* L.

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EVER since physiologic specialization in the pathogen responsible for the rust disease in wheat was established by the work of Stakman and Piemeisel (1916), the task of cataloguing the physiologic races of the three rusts attacking this cereal as also breeding for resistance has received considerable impetus. The latter work has become particularly complicated due not only to the occurrence of a very large number of races which have been identified in each of the rusts but also due to the constant origin of new races.

India has been somewhat fortunate inasmuch as the number of physiologic races in each of the three rusts recorded in this country is very much less than that found in other wheat-growing countries of the world. The earlier work of Mehta (1933) revealed the occurrence of four physiologic races in black rust, two in yellow and two in brown rust. But, subsequently, more races have been isolated, and, at present, they total 38—10 in yellow rust, 12 in brown and 16 in black rust (including three biotypes).

While the occurrence of a fewer number of races in each of the rusts has been a somewhat redeeming feature in India in the work of breeding for rust-resistance, the noteworthy feature of the rust problem in this country is that the wheat crop, particularly that of the northern wheat belt, is attacked almost every year by all the three rusts, though their relative intensity may vary from year to year. The question of breeding for the combined resistance to the three rusts, therefore, assumes special significance in this country.

Genetic studies on rust-resistance have been reported by a number of workers in India, e.g., Pal (1951), Sen and Joshi (1955), Pal *et al.* (1956), Sikka and Rao (1958), Suva *et al.* (1958), and Prasad and Rao (unpublished), but the work of most of them was confined to the study of inheritance of field reaction to the rust. It is only recently that Rao and Agrawal (1960) have reported results of inheritance of seedling reaction to races 24, 40, 42, 75 and 117 and biotype 42B of black rust. Sikka (1955) stressed the importance of intensifying work on the study of seedling resistance.

In the present study, an attempt was made to collect information on the number of genes involved in different resistant parents of *Triticum aestivum* in controlling seedling

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resistance to different races of black rust met with in India. In the present paper, results relating to race 75 and biotype 42B of black rust are reported. Studies with other races of black rust will be reported in subsequent papers.

MATERIAL AND METHODS

The material for this study consisted of the following intervarietal crosses of *T. aestivum*.

1. NP 789 × E 771 (Frondoso)
2. NP 790 × NP 710
3. Pb. C 281 × NP 790
4. Pb. C 591 × NP 790
5. NP 790 × NP 775
6. E 952 (Rionegro) × Pb. C 518

Note : 'E' refers to the accession numbers for the exotic wheats at the Indian Agricultural Research Institute and 'NP' refers to the improved strains bred at the same Institute.

The cross No. 1 was studied against biotype 42B and Nos. 5 and 6 against race 75, while the remaining three crosses were studied with both biotype 42B and race 75.

In all the crosses, only the F_2 generation was studied, except in the cross Pb. C591 ×NP 790 where F_3 was also studied against biotype 42B.

The chief characters of all the varieties, except Rionegro, under the present study were described by Pal, Sikka and Rao (1956), Sikka and Rao (1957), and Rao and Agrawal (1960). The variety Rionegro, received from South America, was found to be a valuable source of resistance to the yellow and brown rusts in India. It is also resistant to a number of black rust races in the seedling stage.

The rust reactions of the varieties used in the present studies to biotype 42B and race 75 are indicated below.

Variety	Type of reaction 42B	Type of reaction 75
E 771	3–4	3–4
E 952	1–2	0,;, 1 & 2
Pb.C 281	4	4
Pb. C 518	4	4
Pb. C 591	4	4
NP 710	4	3 & 4
NP 775	4	4
NP 789	0	0
NP 790	0	0

The salient features of the physiologic races of black rust used in this study are given below.

Biotype 42B

This biotype of race 42 was first noticed by Uppal and Gokhale (1947) while testing the reactions of wheat varieties and hybrids to black rust at Mahableshwar (India). Certain varieties which were highly resistant at that time to races 15, 21, 24, 34, 40, 42 and 75 developed large susceptible pustules, and hence new race or races were suspected. Three pure cultures were isolated from these susceptible pustules. Two isolates when tested were found to be biotypes 42A and 42B.

42B can be differentiated from race 42 by supplementing the 12 standard differentials with the variety Yalta. Yalta is susceptible to biotype 42B and resistant to race 42.

Race 75

The collection made by Mehta in 1930-31 yielded race 75 apart from races 40 and 42. In the words of Mehta (1940), it is rather poorly represented and seems to be steadily disappearing since the year 1933. It is not as virulent as the other races. It is characterized by the non-rupturing of the epidermis of uredosori, and thus can be readily distinguished from the other Indian races.

The genetic material was sown in four-inch pots filled with equal parts of garden soil and F.Y.M. Agra local (*T. aestivum*), which is susceptible to all the races of the three rusts, was used in multiplying the inoculum. The lower surface of the leaves was inoculated after the seedlings had been predisposed. The seedlings were kept covered under humid chambers after inoculation to assure the maximum infection. All precautions that are necessary in a rust glasshouse were taken to avoid dissemination and contamination of the races. The purity of the races was checked from time to time by inoculating the standard differential set.

The reactions were recorded on the basis of standard key drawn by Stakman, Lavine and Loegring (1944) when rust had developed to the point of maximum differentiation. Seedlings showing 0,;, 1 and 2 types of reactions were classified as resistant and those showing X, 3 and 4 types were considered susceptible.

RESULTS

Inheritance of seedling reaction to biotype 42B of black rust

Four crosses, viz., NP 789 × Frondoso, NP 790 × NP 710, Pb. C 281 × NP 790 and Pb. C 591 × NP 790 were studied to find out the mode of inheritance of seedling reaction to this biotype. The results are presented in Table I.

The data in Table I reveal that the reaction to biotype 42B of black rust is controlled by a single dominant gene in all the four crosses. Thus both the sister strains, viz., NP 789 and NP 790, carry one dominant gene for resistance to this biotype.

In one cross, viz., Pb. C 591 × NP 790, F_3 was also studied. Out of the total of 30 families studied, seven were homozygous resistant, 15 segregated like the F_2 and eight proved to be homozygous susceptible. With the P value ranging between 0·95-0·98, this gave a good fit to 1R:2H:1S, as expected.

TABLE I. SEEDLING REACTION IN F_2 OF FOUR INTERVARIETAL CROSSES OF *T. AESTIVUM* TO BIOTYPE 42B OF BLACK RUST

Cross	Number of plants		Total	X^2	P value	Mode of segregation
	Resistant	Susceptible				
NP 789 × E 771	86	21	107	1·647	0·10–0·20	3R : 1S
NP 790 × NP 710	74	26	100	0·0532	0·80–0·90	3R : 1S
Pb.C 281 × NP 790	226	74	300	0·0178	0·80–0·90	3R : 1S
Pb.C 591 × NP 790	149	43	192	0·694	0·30–0·50	3R : 1S

Inheritance of seedling reaction to race 75 of black rust

Five crosses, viz., Pb. C 281 × NP 790, Pb. C 591 × NP 790, NP 790 × NP 710, NP 790 × NP 775 and E 952 × Pb. C 518 were studied to find out the mode of inheritance of seedling reaction to race 75 of black rust. The results are presented in Table II.

TABLE II. SEEDLING REACTION IN F_2 OF FIVE INTERVARIETAL CROSSES OF *T. AESTIVUM* TO RACE 75 OF BLACK RUST

Cross	Number of plants		Total	X^2	P value	Mode of segregation
	Resistant	Susceptible				
Pb.C 281 × NP 790	252	15	267	0·18	0·50–0·70	15R : 1S
Pb.C 591 × NP 790	176	12	188	0·0056	0·90–0·95	15R : 1S
NP 790 × NP 710	300	20	320	0·00	1	15R : 1S
NP 790 × NP 775	290	20	310	0·003	0·95–0·98	15R : 1S
E 952 × Pb.C 518	53	167	220	0·97	0·70–0·80	1R : 3S

The results in the above table reveal that in all the four crosses where NP 790 is the common resistant parent, a ratio of 15R:1S was obtained in F_2, indicating the operation of two duplicate factors in conditioning reaction to race 75. In the cross E 952 (Rionegro) × Pb. C518, the reaction was governed by a single gene with dominance of susceptibility.

DISCUSSION

In the present studies, four crosses were under observation to find out the mode of inheritance of reaction to biotype 42B. In all the four crosses, viz., NP 789 × Frondoso, NP 790 × NP 710, Pb. C 591 × NP 790 and Pb. C 281 × NP 790, the inheritance was simple and could be explained on the assumption of a single gene difference between the parents, with dominance of resistance. The results of the cross Pb. C 591

×NP 790 were also confirmed by studying the F_3 generation, where a ratio of 1R: 2H:1S was obtained.

The studies with this biotype show that both the sister strains, NP 789 and NP 790, carry a single gene for resistance. Since both NP 789 and NP 790 were derived from the same cross, it is likely that the genes governing resistance to this biotype in these two sister selections may be one and the same; and as such, in a practical breeding programme it would suffice if one of these two strains was used for resistance against 42B.

Recently, Rao and Agrawal (1960) have also found that resistance to biotype 42B is governed by a single dominant gene in the crosses Pb. C 273(S)×NP 790(R), NP 775(S)×NP 790 and NP 710(S)×E 1913(R). However, they found that E 581 carried two dominant duplicate genes governing resistance to this biotype in the cross NP 710(S)×E 581(R).

In the four crosses involving NP 790, viz., Pb. C 281×NP 790, Pb. C 591×NP 790, NP 790×NP 710 and NP 790 ×NP 775 studied against race 75, operation of two duplicate dominant genes for resistance was observed. In the cross E 952×Pb. C 518, however, it was found that a single recessive gene of E 952 was concerned in governing resistance.

That NP 790 carries two duplicate dominant genes for resistance to race 75 is also confirmed by the work of Rao and Agrawal (1960) in case of the cross Pb. C 273(S) ×NP 790(R). They found that E 1913 also had two dominant duplicate genes governing resistance in the cross NP 710 (S)×E 1913(R).

SUMMARY

The results of studies conducted to find out the mode of inheritance of seedling resistance to biotype 42B and race 75 of black rust in some intervarietal crosses of *T. aestivum* L. are reported.

The resistance of NP 790 was found to be monogenically dominant over the susceptibility of Pb. C 281, Pb. C 591, and NP 710, when studied against biotype 42B. Similarly, the resistance of its sister selection NP 789 was also monogenically dominant over the susceptibility of Frondoso.

The resistance of NP 790 to race 75 was found to be governed by two duplicate dominant genes in crosses with Pb. C 281, Pb. C 591, NP 710 and NP 775. The resistance of Rionegro in the cross Rionegro×Pb. C 518 was, however, controlled by a single recessive gene.

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RESPONSE OF WHEAT AND BARLEY TO N AND P FERTILIZERS AT BARLEY RESEARCH FARM, GURGAON

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NITROGEN an dphosphorus are the most important elements of plant nutrition. Very little information is available regarding the requirements of these elements for the cereal crops grown in the south-eastern districts (Hariana tract) of the Punjab. Now when the increase in production of food grains is the crying need of the day and when the application of fertilizers to achieve this end is obtaining greater and greater importance, experiments conducted to find out the comparative value of various fertilizers and also to determine the optimum dose of these, assume a special significance. The most important cereal crops, viz., wheat and barley, occupying an area of 10·6 and 2·4 lakh acres, respectively, in the Hariana tract have been neglected so far as their fertilizer requirements are concerned, and the present investigations were undertaken with that objective in view.

Fertilizer experiments have been conducted in the past on various crops by a large number of workers. The use of response curves in determining the optimum doses of different fertilizers and calculating the economics of manuring has been done by various workers, the notable amongst them being Finney (1953), Sukhatme (1941), Panse (1945), Sethi and others (1952) and Yates, Finney and Panse (1953).

MATERIAL AND METHODS

The N and P fertilizer experiments on wheat and barley were conducted at the Barley Research Farm, Gurgaon, during the years 1951-52 to 1954-55. The wheat variety selected for these experiments was C 281 which was bred there and suits admirably the prevalent conditions of the tract. This variety is on the approved list of the Department and is recommended for cultivation both under normal and late-sown conditions. The barley variety used for these experiments was T4, which also is on the approved list of the Department and is recommended for cultivation in the tract.

For both the crops, the fertilizer treatments included 0, 25 and 50 lb. of N in the form of ammonium sulphate and 0, 25 and 50 lb. of P_2O_5 per acre in the form of superphosphate. Both the fertilizers in these doses were tried alone as well as in combination with each other, thus there being nine treatments in all. The layout of the experiment both for wheat and barley was simple randomized blocks with four to six repeats and 1/62 to 1/180 acre net plot-size in different years. One guard row on either side of the plot and two feet border of each plot in either end were discarded at harvest and only the net plot-size was threshed. The superphosphate was drilled before sowing at a depth of four inches approximately, while the ammonium sulphate was applied broadcast on the surface just before the first irrigation. The crops were

raised under conditions prevailing in the tract and all the cultural operations like seed-rate, sowing date, spacing, hoeing, etc., were the same as are in vogue in the tract.

RESULTS

Barley

The results obtained in the year 1951-52 are given in Table I.

TABLE I. AVERAGE YIELD OF GRAIN PER ACRE IN LB. DURING 1951-52

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D. per acre
P_0 (control)	1,313	1,732	2,167	1,737	377 lb.
P_1 (25 lb.)	1,647	2,123	2,226	1,999	
P_2 (50 lb.)	1,724	1,863	2,066	1,884	
Average	1,561	1,906	2,153		

(i) C.D. of the difference of two marginal means 377 lb.
(ii) C.D. per acre for the means in the body of the Table 653 lb.
(iii) S.E.M. per acre 317 lb.

In the detailed analysis of variance for treatments, the nitrogen effect was highly significant whereas that of P_2O_5 treatments and interactions of the two fertilizers were not significant.

The results obtained in 1952-53 are presented in Table II.

TABLE II. AVERAGE YIELDS OF GRAIN PER ACRE IN LB. IN 1952-53

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D.@ 5% level
P_0 (control)	2,325	2,696	2,746	2,589	183 lb.
P_1 (25 lb.)	2,500	2,646	2,694	2,613	
P_2 (50 lb.)	2,149	2,591	2,356	2,365	
Average	2,325	2,644	2,599		

(i) C.D. of the difference of two marginal means .. .. 183 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 317 lb.
(iii) S.E.M. per acre .. .. 156 lb.

These results too have shown almost a similar trend as in the previous year. The nitrogen treatment effect is highly significant and the P_2O_5 effect is also significant, but the interaction of the different treatments is not significant.

The results of 1953-54 are summarized in Table III.

TABLE III. AVERAGE YIELDS OF GRAIN PER ACRE IN LB. IN 1953-54

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D.@ 5% level
P_0 (control)	1,080	1,649	1,527	1,419	113
P_1 (25 lb.)	1,072	1,566	1,746	1,461	
P_2 (50 lb.)	1,021	1,640	1,685	1,449	
Average	1,058	1,618	1,653		

(i) C.D. of the difference of marginal means .. .. .. 113 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 196 lb.
(iii) S.E.M. per acre .. .. 95 lb.

Here, the detailed analysis for treatments showed that the nitrogen treatment effect only was statistically significant and the other treatments (P_2O_5) and interactions of the two fertilizers were not significant.

Combined analysis of three years' data: The results of three years, given above, showed almost similar trend and, therefore, a combined analysis of three years data was carried out. The individual plot yields obtained in each year were worked out on a 1/80-acre basis and were subjected to individual analysis. The Bartlett's test of homogeneity of variance showed that the error variances were highly heterogeneous and, therefore, a weighted analysis for testing the significance of interaction between years and treatments as suggested by Cochran and Cox (1950), was attempted. The X^2 obtained for interaction with 11·43 degrees of freedom was 19·82 which proved that the interaction was significant. The results of the combined analysis of three years' data along with an analysis of variance are given in Tables IV and V.

TABLE IV. AVERAGE COMBINED YIELDS PER ACRE IN LB.

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D.@ 5% level
P_0 control)	1,681	2,122	2,233	2,012	163 lb.
P_1 (25 lb.)	1,849	2,189	2,290	2,109	
P_2 (50 lb.)	1,706	2,112	2,082	1,967	
Average	1,745	2,141	2,202		

(i) C.D. of the difference of two marginal means .. .. 163 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 282 lb.
(iii) S.E.M. per acre .. .. 94 lb.

The study of the analysis of variance reveals that the results are highly significant for years as well as for treatments. Amongst the treatments, only nitrogen shows high significance whereas the P_2O_5 and interaction of nitrogen and P_2O_5 are not significant,

TABLE V. AVERAGE OF VARIANCE FOR COMBINED ANALYSIS

Due to	Degree of freedom	S.S.	M.S.	O.F.	Significant or not
Total	26	67,116·3			
Years	2	50,470·3	25,235·15	100·9	Significant
Treatment	8	12,651·0	1,581·38	6·32	do.
N	2	11,575·6	5,787·81	23·15	do.
P	2	821·4	410·70	1·64	Not significant
N×P	4	254·0	63·50	..	do.
Error	16	3,995·0	250·0		

Economics of fertilizers: With a view to comparing the relative rate of response of nitrogen in barley crop, the average values of yield were subjected to a more detailed study. To estimate the optimum dose and also to work out economics of fertilizers, a quadratic response curve was fitted and it was found that when barley was selling at Rs. 12·00 per maund and the fertilizer cost 84 nP. per lb., the optimum nitrogen dose came to 32·51 lb. per acre. Similarly, the optimum doses of nitrogen per acre and the net profits that accrued when barley sold at Rs. 12·00, 14·00 and 16·00 per maund, are given in Table VI.

TABLE VI. ECONOMICS OF FERTILIZER APPLICATIONS

When barley is sold at	Rs. 12·00	Rs. 14·00	Rs. 16·00	per md.
Optimum nitrogen doses in lb. per acre	32·51	34·13	35·34	
Price of optimum dose in rupees	27·31	28·67	29·69	
Price of additional produce in rupees	66·60	79·24	91·68	
Net profits in rupees	39·29	50·57	61·99	

The net profits accruing to the farmer by application of varying doses of nitrogen to the barley crop are, thus, ranging from Rs. 39·29 to Rs. 61·99 per acre, depending upon the market rates. The comparison of 25 and 50 lb. N doses per acre and control at prevailing market rate, viz., Rs. 16·00 per maund is given in Table VII.

TABLE VII. COMPARISON OF VARIOUS DOSES OF NITROGEN FOR NET PROFITS OVER CONTROL

Treatment	Value of fertilizer Rs.	Average yield per acre	Increased yield of grain over control per acre	Value of increased production per acre Rs.	Net profits per acre Rs.
Control	..	1,745	..	..	..
25 lb. N per acre	21·00	2,141	396	77·00	56·00
50 lb. N per acre	42·00	2,202	457	90·00	48·00

The lower dose of 25 lb. N per acre gives higher net profits than the higher dose of 50 lb. per acre, their respective net profits being Rs. 56 and Rs. 48 per acre, respectively.

The other treatments, viz., P_2O_5 alone at the rate of 25 and 50 lb. per acre and in combinaton with the nitrogen doses resulted in much less net profits, and in some cases (viz., 50 lb. P_2O_5 alone or in combination with 50 lb. nitrogen per acre) they gave even negative results.

Wheat

The results obtained in the year 1952-53 are given in Table VIII.

TABLE VIII. AVERAGE YIELDS OF WHEAT PER ACRE IN LB. DURING 1952-53

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D. per acre
P_0 (control)	1,201	1,512	1,739	1,484	90 lb.
P_1 (25 lb.)	1,295	1,568	1,713	1,525	
P_2 (50 lb.)	1,396	1,616	1,794	1,602	
Average	1,297	1,565	1,749	..	

(i) C.D. of the differences of two marginal means .. .. 90 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 156 lb.
(iii) S.E.M. per acre .. .. 77 lb.

In the detailed analysis of variance for treatments, the nitrogen treatment effect was highly significant while that of the P_2O_5 treatment and interaction of the two treatments ($N \times P$) were not significant.

The results obtained in the year 1953-54 are presented in Table IX.

TABLE IX. AVERAGE YEILDS OF WHEAT PER ACRE IN LB. DURING 1953-54

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D. per acre in lb.
P_0 (control)	2,088	2,274	2,486	2,283	276
P_1 (25 lb.)	1,782	2,260	2,467	2,170	
P_2 (50 lb.)	2,178	2,081	2,554	2,271	
Average	2,016	2,205	2,502	..	

(i) C.D. of the differences of two marginal means .. .. 276 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 478 lb.
(iii) S.E.M. per acre .. .. 232 lb.

In the detailed analysis of variance for treatments the nitrogen effect was highly significant whereas that of P_2O_5 and interaction of the two treatments ($N \times P$) were not significant.

The results obtained in the year 1954-55 are summarized in Table X.

TABLE X. AVERAGE YIELDS PER ACRE IN LB. DURING 1954-55

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D. per acre
P_0 (control)	1,188	1,942	2,587	1,906	166 lb.
P_1 (25 lb.)	1,137	2,047	2,783	1,989	
P_2 (50 lb.)	1,242	2,068	2,605	1,972	
Average	1,189	2,019	2,658		

(i) C.D. of the differences of two marginal means .. .. 166 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 288 lb.
(iii) S.E.M. per acre .. .. 140 lb.

In the detailed analysis of variance for treatments nitrogen effect, as in the previous two years was highly significant while that of the P_2O_5 and interaction ($N \times P$) were not significant.

Combined analysis of three years' data: As in the case of results obtained for barley, the results of three years' trials on wheat crop were also of similar trend. Likewise, the individual plot yields obtained were worked out on a 1/80-acre basis and a combined analysis of three years data was carried out. Bartlett's test of homogeneity of variances indicated that the error variances were highly heterogeneous, as was observed in the case of barley. Consequently, in order to test the significance of treatment $\times$ year (interaction), a weighted analysis was attempted in this case also. The X^2 for interaction is obtained as 27·92 with 11·43 degrees of freedom. This reveals that the interaction in question is significant. The results of the combined analysis of the three years' data and analysis of variance are given in Tables XI and XII.

TABLE XI. AVERAGE COMBINED YIELDS PER ACRE IN LB.

Treatment	N_0 (control)	N_1 (25 lb.)	N_2 (50 lb.)	Average	C.D. per acre
P_0 (control)	1,495	1,911	2,274	1,893	266 lb.
P_1 (25 lb.)	1,406	1,959	2,326	1,897	
P_2 (50 lb.)	1,609	1,921	2,315	1,948	
Average	1,503	1,930	2,305	..	

(i) C.D. of the difference of two marginal means .. .. 266 lb.
(ii) C.D. per acre for the means in the body of the Table .. .. 461 lb.
(iii) S.E.M. per acre .. .. 154 lb.

The analysis of variance shows very high significance for years and for treatments. Among the treatments, only the N is highly significant whereas P_2O_5 and interaction of the two (N and P_2O_5) are not significant.

TABLE XII. ANALYSIS OF VARIANCE FOR THE COMBINED ANALYSIS

Due to	Degree of freedom	S.S.	M.S.	O.F.	Significant or not
Total	26	60,063·6	..		
Years	2	21,348·4	10,674·2	15·93	Significant
Treatments	8	27,999·0	3,499·9	5·22	do.
N	2	27,338·2	13,669·1	20·40	do.
P	2	161·0	80·5	..	Not significant
N and P	4	500·0	125·0	..	do.
Error	16	10,716·0	670·0		

Economics of fertilizers: The results obtained in case of wheat are different from those in barley in that whereas in the barley crop the difference in response between 25 and 50 lb. nitrogen doses were not statistically significant, the responses of these doses in wheat differed significantly. In all the three years of trial, as also in case of combined analysis, the 50 lb. nitrogen dose outyielded the 25 lb. nitrogen dose significantly. The response increased linearly with the level of nitrogen, indicating thereby that the dose of nitrogen for wheat could be increased beyond the 50 lb. nitrogen dose, the highest level of nitrogen employed here. Under the circumstances, the optimum dose for wheat cannot be determined with the data available.

The net profits accruing to the farmer by the application of varying doses of nitrogen to wheat crop can, however, be worked out. They are given in Table XIII on the basis of prevalent market rate of Rs. 18·00 per maund.

TABLE XIII. COMPARISON OF VARIOUS DOSES OF NITROGEN FOR NET PROFITS OVER CONTROL

Treatment	Value of fertilizer Rs.	Average yield per acre	Increased grain yield over control lb.	Value of increased production Rs.	Net profit per acre Rs.
Control	..	1,503	..	..	..
25 lb. N	21·00	1,930	427	93·5	72·5
50 lb. N	42·00	2,305	802	174·6	132·6

The foregoing figures indicate that 50 lb. nitrogen dose has given the highest net profit of Rs. 132·6 against Rs. 72·5 per acre accruing from the 25 lb. nitrogen dose. The P_2O_5 doses at the rate of 25 and 50 lb. per acre gave negative results in some cases and resulted in net loss, while the combined doses of nitrogen and P_2O_5 gave much lower profits as compared to the nitrogen doses alone.

DISCUSSION

The results presented in the preceding data have conclusively proved the dire lack of nitrogen in the soils represented by the one at the Barley Research Farm, Gurgaon. The addition of nitrogenous fertilizer to both the wheat and barley crops resulted in enhanced yields in all the three years of trial. The 25 lb. dose in case of barley has been found to be the best and this dose was not superseded by significant margins by the 50 lb. dose. In the case of wheat, however, the higher doses of nitrogen yielded significantly higher than the 25 lb. nitrogen dose, which in turn superseded the control in a similar way. As the response increased linearly with the increasing dose of nitrogen, the optimum dose could not be determined for wheat. The optimum dose for wheat may lie even beyond 50 lb. nitrogen per acre. The difference in nitrogenous requirements for these two crops lies in their maturity period, plant size, growth and the usual outturns per unit area.

The P_2O_5 constituent was found to be abundantly available in the soils of the tract and further addition of this element did not result in any enhanced outturns. The results in some cases also indicate a tendency for deprecating the final outturns by the addition of higher dose of this fertilizer. The P_2O_5 has, no doubt, not shown any effect on the yields, yet the effect of this element on ripening, development of grains, strength of straw, etc., cannot be minimized and, unfortunately, no data on these aspects were collected.

The interaction of the two fertilizers was found to be not significant in all the three years of trial, showing thereby that the addition of the P_2O_5 fertilizer in conjunction with the nitrogen also did not show any effect on the final outturns of these crops.

The combined analysis of variance in the two crops showed differences between the year to year effects. This fact shows a high influence of seasonal variations on the crops concerned. One thing more is also indicated, i.e., the variation on account of years is much higher in barley as compared to wheat, showing thereby the strong influence of seasonal variations on the former crop. This is, perhaps, accounted by the fact that barley is a short-duration crop as compared to wheat.

SUMMARY

Three doses of N, viz., 0, 25 and 50 lb. per acre in the form of ammonium sulphate and three doses of P_2O_5 viz., 0, 25 and 50 lb. per acre in the form of superphosphate were tried individually as well as in combination on wheat and barley crops at the Barley Research Farm, Gurgaon. The results obtained have shown a very high effect of nitrogenous fertilizer on the final outturns of these crops. The optimum dose of nitrogen at the present price and cost was found to be about 33 lb. of nitrogen per acre for barley, the profit being about Rs. 40·00 per acre when barley is sold at Rs. 12·00 per maund. At the rate of Rs. 16·00 per maund, however, the 25 lb. nitrogen dose gave net profit of Rs. 56·00 per acre. In the case of wheat, the profit increases proportionately with the increasing dose up to the highest level of 50 lb. nitrogen per acre. At this level, the net profit is about Rs. 132·00 per acre. The optimum dose of nitrogen for wheat crop may, however, lie beyond 50 lb. nitrogen per acre.

The P_2O_5 fertilizer either alone or in combination with nitrogenous fertilizer did not show any marked effect on the final yields of both the crops. With higher dose of P_2O_5, there was a tendency for deprecating the yields in both the crops.

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A COMPARATIVE STUDY OF THE GANGETIC ALLUVIUM UNDER CULTIVATION AND AFFORESTATION

I. PHYSICAL AND PHYSICO-CHEMICAL PROPERTIES

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Continuous cultivation on the one hand and the forest cover on the other, are known to exert a profound influence on the physical and other soil properties. Jenny (1933) observed that 60 years of continuous cultivation of Putnam silt loam in Missouri (U.S.A.) led to a 33 per cent decrease in the available bases with a corresponding adverse effect on the soil aggregates. Bradfield and Richards (1936) similarly observed a decrease in the porosity of clay soil in north western Ohio from 16 to 18 per cent below that of relatively virgin forest during 40 years of farming. The effects of cultivation on such soil properties as pore space, water-holding capacity, sticky point moisture content, rate of percolation, character and extent of available nutrients, etc., have been investigated by various workers like Wollney (1890), Illmenjew (1935), Rostozeva and Avaeva (1935), Page *et al.* (1947), Browning *et al.* (1945), Lutz *et al.* (1947), McVickar *et al.* (1947), Mooser (1939), Helster and Shelton (1937), and Mazurak *et al.* (1953). The influence of forest vegetation upon soil properties such as morphology, hydrological status and reaction, etc., has been investigated by Sozykin (1946), Hopkins and Donahue (1939), Spurr (1940), Auten (1941 and 1945), and others. However, detailed information on the comparative influence of the afforestation and of cultivation on soil properties is lacking. The authors, therefore, undertook a study of the various soil properties of an afforested land and the nearby continually cultivated soil of the college farm.

MATERIAL AND METHODS

The soils of Uttar Pradesh form a major portion of the widely known great Indo-gangetic plain, consisting of the soils mostly derived from the disintegration of Himalayan gneiss and schists. These alluvial plains were covered by dense forests. According to the epics like "Ramayan" and "Mahabharata" and the accounts of Chinese travellers as far back as (600 B.C.) as well as Greek emissaries, the now almost treeless tract of central U.P. was covered with thick dismal forests in those days. The

primeval forests were cut down by the emigrants to the Indo-gangetic basin for providing habitation, cultivation and pasture. The fertility accumulated through the ages was gradually lost and the infertile soil eroded badly, forming the famous ravines of the rivers of Jamuna and Ganga. These ravines have increased rapidly and have engulfed thousands of acres of fertile land.

Until very recently, practically nothing was done to check these increasing ravines. At present, however, serious attention is being paid to stop this erosion. Amongst the various measures taken to control this erosion, afforestation is a major one. In 1917, George Berney Allen undertook to reclaim the Gangetic ravines of Kanpur by afforestation and was successful to a considerable extent in stabilizing the soil. The forest is now known as Allenbagh Forest and has been taken over by the U.P. Forest Department. As the afforested area is near the Government Agricultural College Students' Instructional Farm, which remained under continuous intensive cultivation, these two sites were considered most suitable for a comparison of the effect of continuous cultivation and forest cover on soil properties.

The profiles sampled are located in the Students' Instructional Farm (plot No. 193) and the Allenbagh Forest (plot No. 4), Kanpur. The farm and the forest lie within a distance of half a mile and are situated about two miles away from the river Ganga. The profiles selected on the basis of field studies are representatives of the respective soils. The amount of precipitation of the region varies from 32 to 26 in. per annum. The mean monthly maximum temperature rises to about 110° F. or more in May and drops to 45° or so in January. Lang's factor for the area is 31·8 mm. per °C. and Meyer's ratio approximately 97 (Agarwal and Mehrotra, 1952 and 1953).

The general topography of the cultivated plot is nearly level, while the forest is situated on an undulating ground sloping towards the central lake. The soils are well drained.

The Farm has been under cultivation since 1882. Since 1912, when the Farm was taken over by the College for experimental and demonstration purposes, it has been kept under intensive cultivation. Plot No. 193 was mostly occupied by vegetables and the cultivation in this plot has been very intensive as is shown by the cropping sequence followed during the last ten years. It may be noted from the sequence of crops given below that the plot was not left fallow even for a single season.

Year	Season	
	Kharif	*Rabi*
1945	*Sanai*	Wheat
1946	Vegetables	Vegetables
1947	Vegetables	Vegetables
1948	Green manuring	Potato
1949	*Colocasia*	Potato
1950	Maize for cobs	Wheat
1951	*Chari*	Gram
1952	Brinjals	Brinjals
1953	Vegetables	Vegetables
1954	Brinjals	Brinjals

The Farm records show that the plot was heavily manured with F.Y.M., compost and artificial fertilizers. The Allenbagh forest area before 1917 was partly under cultivation and partly under Gangetic ravines. In 1917, G. B. Allen fenced about 300 acres of land near the Farm to allow the natural vegetation to develop. Water was allowed to accumulate in the central low-lying area of the forest and gradually an artificial lake developed.

The predominating trees growing in the forest are *Azadirachta indica*, the characteristic tree of the semi-arid region; *Acacia arabica*; *Tectona grandis*; *Feronia elephantum*; *Dalbergia sissoo*, eucalyptus, *Inga dulcis* and *Eugenia jambolana*. A few trees of *Prosopis spicigera* are also found growing here and there.

The samples were collected from the various morphologically differentiated horizons and prepared for laboratory analysis using procedures similar to those described by Piper (1950). The mechanical fractions were separated by the International pipette method (Wright, 1939) and $CaCO_3$ was estimated by determining the loss of CO_2 with the Schrodter apparatus. The *p*H values of the samples were determined by the colorimetric method of Kuhn (1930) using Bromthymol blue Hellige Colour disc. Of Single Value Physical Constants, density and pore space were determined by the usual methods, water-holding capacity and sticky point moisture by the method described by Piper (1950). The rate of water percolation was determined by allowing a known volume of water to percolate through a known weight of soil column. The total exchange capacity and exchangeable Ca and Mg determinations were carried on according to the procedure described by Piper (1950).

Morphological characteristics of the soil profiles

Horizon	Depth	Description
		Cultivated soil
1.	0-6 in.	Greyish sandy loam, loose and friable, full of grass roots, *p*H 6·9, noncalcareous to 4N acid.
2.	6 in.-1 ft. 3 in.	Brownish grey sandy loam, slightly compact, fewer grass roots, *p*H 6·4, non-calcareous to 4N acid.
3.	1ft. 3 in.-2 ft.	Brown sandy loam, slightly compact, scanty grass roots, *p*H 6·4, non-calcareous to 4N acid.
4.	2-3 ft.	Dark brown sandy clayey loam, hard and compact, heavy textured, yellow concretions of pinhead size, few insect channels with ochrous mottling, *p*H 6·8, non-calcareous to 4N acid.
5.	3-4 ft.	Dark brownish grey sandy loam, less compact than the fourth horizon, few black and yellow concretions of pinhead size, *p*H 6·2, non-calcareous to 4N acid.
6.	4-5 ft.	Brownish yellow sandy loam, loose, *p*H 6·8, non-calcareous to 4N acid.
7.	5-5½ ft.	Brownish yellow sandy loam, *p*H 6·9, notably calcareous to 4N acid.
8.	5½-6 ft.	Grey sandy loam, cloddy and hard, numerous fairly large sized *kankar* forming a hard pan, *p*H 7·8, highly calcareous to 4N acid.

Horizon	Depth	Description
		Forest soil
1.	0-6 in.	Blackish grey sandy loam, loose, small *kankar* ($CaCO_3$ nodules) present, filled with grass roots, *p*H 7·4, slightly calcareous to 4N acid.
2.	6in-1 ft. 3 in.	Yellowish grey clay loam, small *kankar*, fine roots well distributed, *p*H 7·1, slightly calcareous to 4N acid.
3.	1 ft. 3 in.-2 ft.	Brownish yellow clay loam, compact, *kankar* and few rusty spots, tree roots, *p*H 7·4, calcareous to 4N acid.
4.	2-3 ft.	Brownish yellow clay loam, compact, *kankar* and root channels with ochrous mottling, *p*H 7·0, calcareous to 4N acid.
5.	3-4 ft.	Yellowish clay loam, compact, numerous *kankar* with rusty mottling, tree roots, alkaline to BTB, *p*H 7·8, highly calcareous to 4N acid.
6.	4-5 ft.	Yellowish clay loam, compact, few *kankar* tree roots, *p*H 7·3, calcareous to 4N acid.
7.	5-6 ft.	Yellowish silty loam, compact, *kankar* more numerous, occasional greyish streaks alkaline to BTB, *p*H 7·6, calcareous to 4N acid.

TABLE I. MECHANICAL COMPOSITION, *p*H AND $CaCO_3$ (PER CENT ON AIR-DRY BASIS)

Horizon	Depth (in inches)	Coarse sand	Fine sand	Silt	Clay	*p*H	$CaCO_3$
				Cultivated soil			
1.	0–6	0·68	60·14	21·52	12·16	6·9	0·71
2.	6–15	0·21	54·80	23·28	17·95	6·4	0·64
3.	15–24	0·36	51·98	22·07	20·72	6·4	0·63
4.	24–36	0·23	50·52	22·27	22·60	6·8	0·69
5.	36–48	0·18	55·60	22·50	18·60	6·2	0·59
6.	48–60	0·23	64·21	22·29	12·26	6·8	0·87
7.	60–66	0·67	60·96	21·50	10·47	6·9	8·27
8.	66–72	1·55	57·40	19·95	9·87	7·8	11·82
				Forest soil			
1.	0–6	0·15	46·33	33·72	16·50	7·4	4·19
2.	6–15	0·73	40·35	43·55	13·85	7·1	3·86
3.	15–24	1·02	36·07	40·81	21·15	7·4	3·60
4.	28–36	0·45	28·56	42·21	22·10	7·0	3·16
5.	36–48	0·52	33·48	42·45	19·54	7·8	7·11
6.	48–60	0·35	30·23	42·79	14·34	7·3	7·10
7.	60–72	0·65	31·41	51·17	13·15	7·6	7·11

RESULTS

Mechanical composition, $CaCO_3$ and pH (Table I)

The mechanical analysis of the profiles confirms the field observations. The salient feature of both the profiles is the higher clay content of the fourth horizon. It appears that the clay has leached from the surface horizons of both the profiles and has accumulated in the fourth horizon. The horizon of alluviation of clay in the forest soil seems to be the second one, and the leaching of clay here seems to be due to the action of various products of decomposing organic matter. The predominance of fine sand in the cultivated soil profile indicates the sandy nature of its parent material while the higher silt content of the forest soil points to its development on a silty parent material.

In the cultivated soil, $CaCO_3$ has more or less completely leached down the profile and has accumulated at about 5 to 6 ft. in the form of fairly large nodules (*kankar*). The $CaCO_3$ content of the first six horizons, viz., up to the depth of 5 ft. lies between 0·63 and 0·87 per cent while below 5 ft. it ranges from 8·27 to 11·82 per cent. In the forest soil profile, the $CaCO_3$ content gradually decreased from 4·2 to 3·2 per cent with the depth till 3 ft. after which it abruptly increased to 7·1 per cent, remaining constant in the lower horizons. The distribution of $CaCO_3$ in the forest soil profile indicates a lesser leaching than in the cultivated soil profile.

The *p*H values in the cultivated soil profile vary from 6·2 to 7·8, indicating the increase in alkalinity with the depth till it approaches 7·8 in the last $CaCO_3$ accumulation horizon. The reaction of the forest soil profile on the other hand is fairly constant, varying between 7-7·6, i.e., generally towards the alkaline side.

Single value physical constants (Table II)

The pore space, water-holding capacity and sticky point moisture content depend upon the structure and texture of various horizons. The higher porosity and the lower water-holding capacity and sticky point moisture of the surface horizon of both the profiles indicate the loose structure and coarser texture of these horizons. As the clay content increased in the lower horizons the water-holding capacity, and sticky point moisture also increased with the decrease (12 per cent) in the porosity. The decrease in porosity is due to the clogging of the pores by the alluviated clay. The pore space is below 50 per cent in both the profiles. The higher pore space in the last horizon of the cultivated soil seems to be due to the large calcareous nodules. The higher water-holding capacity and sticky point moisture of the forest soil seem to be due to the higher clay and silt contents.

In the cultivated soil profile, the rate of percolation decreases with the depth. The decreasing values in lower horizons tend to show an increasing degree of compactness. In the last horizon, the percolation rate is higher, 4·77 cc./hr., due to the open structure of the horizon caused by the presence of large calcium carbonate nodules. A similar trend of decreased percolation with the depth is observed in the forest soil profile.

TABLE II. SINGLE VALUE PHYSICAL CONSTANTS (ON AIR-DRY BASIS)

Horizon	Depth (in inches)	True density	Pore space	Water-holding capacity %	Sticky point moisture %	Rate of percolation cc./hr.
			Cultivated soil			
1.	0–6	2·51	45·11	37·54	20·74	5·72
2.	6–15	2·54	43·94	36·72	19·04	3·27
3.	15–24	2·57	43·67	37·62	20·85	3·10
4.	24–36	2·68	39·84	39·81	21·64	2·50
5.	36–48	2·59	42·39	37·82	19·76	2·32
6.	48–60	2·60	41·06	36·25	19·66	1·92
7.	60–66	2·61	40·48	35·19	18·99	2·50
8.	66–72	2·32	51·53	35·17	17·99	4·77
			Forest soil			
1.	0–6	2·56	47·21	39·79	23·69	3·45
2.	6–15	2·61	46·15	38·68	23·89	3·17
3.	15–25	2·63	43·81	40·65	24·33	2·97
4.	24–36	2·72	40·15	41·72	27·75	2·85
5.	36–48	2·41	47·34	39·63	27·37	3·60
6.	48–60	2·62	44·15	38·43	26·42	2·90
7.	60–72	2·67	42·45	37·91	27·00	2·80

Exchange Studies (Table III)

The total cation exchange capacity of both the soils is not high. The total exchangeable metal cations increase with the depth in both the profiles. In general, the forest soil profile is richer in cations than the cultivated one.

As is clear from the table, both the soils have attained a high degree of base saturation and Ca is the dominant cation in the exchange complex, amounting approximately to 89 per cent. A comparative lower base and Ca saturation of the surface horizon of the cultivated soil seems to be due to the leaching of bases and the consequent replacement of Ca by H ions which also lower the *p*H of the soil. An increase of the cation exchange capacity in the lower horizons of the forest soil profile in spite of the decrease in the clay content seems to be due to the higher silt content of these horizons.

In the cultivated soil profile, the exchangeable magnesium values lie between 1·01 me. and 1·93 me. per cent, while in the forest profile the values lie in the range of 2·12 to 2·96 me. per cent. It is interesting to note that not only the exchangeable magnesium content is higher in the forest soil profile, but it also increases downwards with the depth.

TABLE III. BASE EXCHANGE VALUES (ME. PER CENT ON AIR-DRY BASIS)

Horizon	Depth (in inches)	Total cation exchange capacity	Total exchangeable metal cations	Exchangeable Ca	Exchangeable Mg
		Cultivated soil			
1.	0–6	22·40	18·12	13·34	1·41
2.	6–15	18–35	16·45	13·48	1·01
3.	15–24	19·45	17·75	14·39	1·93
4.	24–36	21·50	19·47	16·90	1·56
5.	36–48	21·65	20·25	16·05	1·47
6.	48–60	21·85	20·17	17·33	1·59
7.	60–66	22·30	20·12	17·51	1·61
8.	66–72	23·10	20·10	18·91	1·63
		Forest soil			
1.	0–6	24·15	20·32	16·51	2·12
2.	6–15	23·20	21·15	16·98	2·42
3.	15–24	23·35	21·62	17·33	2·47
4.	24–36	24·90	22·12	17·97	2·69
5.	36–48	24·95	23·05	18·51	2·71
6.	48–60	25·15	23·12	19·43	2·95
7.	60–72	25·20	23·32	20·17	2·96

DISCUSSION

The physical and physico-chemical compositions of the cultivated and afforested soils reveal five noteworthy features, viz.,

(1) the greater mobilization of clay from the surface horizons of the cultivated soil profile and its accumulation in the fourth horizon;

(2) the accumulation of $CaCO_3$ in the last horizon of the cultivated soil profile in the form of hard semi-indurated $CaCO_3$ nodules (*kankar*);

(3) higher porosity, water-holding capacity, sticky point moisture content in the forest soil profile;

(4) higher cation exchange capacity and the total exchangeable metal cations in the forest profile; and

(5) the *p*H of the forest soil towards alkaline side and of cultivated soil towards acidic side in the upper horizons of both the profiles.

The characteristic physical feature of these soils is the mechanical translocation of clay from the surface horizons, especially in the cultivated soil, and its accumulation

in the lower horizon causing it to be more or less compact and of somewhat darker colouration. The accumulation of clay in the lower horizons seems to be due to the genetic factors of soil formation intensified by continuous cultivation. Among the characteristic features of the arid steppe type of soil formation, Karvkav (1937) singles out the accumulation of fine silt and clay in the 'b' horizon. But a comparison of the surface soil of both profiles shows that the low clay content of cultivated soil points to the influence of continuous cultivation, manuring and heavy irrigations in the mechanical translocation of the clay from the surface horizons. Helster and Shelton (1937) have also shown that long-time fertilization and cropping practices cause a reduction in the surface clay. In one case, they found a decrease of 3·2 per cent of clay and 4·7 per cent of silt. Mooser (1939) has confirmed these findings. It appears that the agricultural practices disturb the soil and tend to increase the percolation rate of the soil. Musgrave and Free (1936) report, for example, that the infiltration rates of water into a field soil (a) in natural packing (b) cultivated 4 in. deep (c) cultivated 6 in. deep were 0·85 in., 1·77 in. and 1·87 in. per minute, respectively. Table II shows an increase of 2·3 cc./hr. in the percolation of water in the cultivated soil over forest soil. Thus, during the periods of torrential rainfall the clay is likely to be carried away with the percolating waters.

The loss of carbonate and other bases with the accompanying low *p*H (below 7) has further helped in the leaching of clay. The forest on the other hand by helping in maintaining higher base content, *p*H and $CaCO_3$, has better conserved the clay in the surface horizons.

Another characteristic of these soils is the presence of large calcium carbonate nodules in the profile. Both the profiles appear to have developed on the calcareous alluvium. The cultivated soil very much resembles the Gorakhpur Type 2, the leached calcium soil with a layer of $CaCO_3$ accumulation at the bottom, described by Agarwal and Mukherjee (1951). The decalcification process represents the dynamics of this type. The upper horizons are free of $CaCO_3$. On the other hand, the afforested soil is richer in $CaCO_3$ and has not been subjected to such an intense decalcification. Cultivation, inorganic fertilizers, the sandy nature and high percolation rate of the cultivated soil seem to be responsible for such decalcification.

It is clear from the data that though the cation exchange capacity is not higher than 80 per cent, the exchange complex is made up of Ca in both the soils except in the first horizon of the cultivated soil where decalcification has affected even the Ca in the exchange complex. In general, the higher exchangeable Ca: Mg ratio in the cultivated soil indicates that this soil has lost Mg also and may respond to Mg application. The high cation exchange capacity of the forest soil is partly due to higher silt content and partly due to the organic matter. Similarly, the higher exchange capacity of the surface soil in spite of the alluviation of the colloidal fraction illustrates the role of silt and fine sand and also organic matter in the exchange reactions.

It is interesting to note that in spite of fairly thick subtropical forest cover, the *p*H of the forest soil remained towards the alkaline side and showed rapid and complete mineralization of the forest litter and produced alkaline ash instead of intermediate organic acids produced under temperate conditions. On the other hand, the use of fertilizers and irrigation lowered the *p*H of the soil by removing the calcium reserves,

SUMMARY

A detailed comparative study of the physical, and physico-chemical properties of the intensively cultivated and afforested soil profiles is recorded. The results indicate that intensive cultivation exerts a profound influence on the soil genesis through the modification of the above-mentioned properties, and tends to reduce the fertility of the soil. The forests, however, under semi- and subtropical conditions help to regain the lost fertility of the soil and help in counteracting to a certain extent the destructive soil processes, viz., decalcification, etc., introduced by the use of fertilizers and frequent irrigation. The decomposing forest litter does not affect the *p*H of the soil while cropping lowers it.

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NUTRITIVE VALUE OF MAIZE AS INFLUENCED BY MANURES AND FERTILIZERS

II. VITAMINS AND AMINO-ACIDS

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THE effect of manures and fertilizers on the chemical composition of maize is being reported separately.

This paper deals with certain vitamins and amino-acids. So far as vitamins are concerned, this study is restricted to thiamine, riboflavin and niacin in view of their greater dietary importance. Their requirement in the growth and well-being of animals is also better understood, while in the case of amino-acids only methionine, cystine and tryptophane have been studied. Methionine and cystine are the sulphur-containing amino-acids whose importance in nutrition has long been recognized. These amino-acids furnish the basis for the building up of important sulphur-containing substances which play important roles in metabolism. The incidence of pellagra in human beings taking maize as the chief article of diet, has been attributed to the deficiency of either niacin or tryptophane. Knowledge about the niacin and tryptophane contents of maize is, therefore, of special interest. Some interesting observations were reported by workers abroad on the content of vitamins and amino-acids in maize grains as influenced by soil treatments (Hunt *et al.*, 1950; Hamilton *et al.*, 1951; Sauberlich *et al.*, 1953; Flynn *et al.*, 1954). But no information is available when this grain is grown under soil and climatic conditions prevailing in India. In view of the importance of this cereal crop in India, studies on this grain raised with different manurial treatments at Pusa (Bihar) were taken up.

MATERIAL AND METHODS

Yellow maize was raised with different manurial treatments, as given under Table I, in the Permanent Manurial and Rotational Experiments (old series A) at Pusa, Bihar during 1955. This manurial experiment was started in 1908 and modified in 1929. Since then the treatments and rotations have been the same year after year. The difference between the plots can, therefore, be considered as well established and stabilized. The different plots are separated by well-defined demarcation lines. In this old series the plots were not replicated. The varieties of crops used in the rotation are maize yellow, barley NP 21, wheat NP 52 and *arhar* NP 80. The area of each plot is one-fourth of an acre and the plots are situated on one single strip of flat land. The details of this experiment, nature of the Pusa soil and description of the different treatments were described earlier (Gupta and Das, 1954).

The representative samples of the maize grain collected from each plot were ground to a uniform fineness in a grinding machine, and the uniform portion of the sample was taken from each plot for analysis.

For the estimation of vitamins and amino-acids, dried maize samples were first made free from fat by extracting them with petroleum ether. Thiamine, riboflavin and niacin were, then, estimated microbiologically with the help of *L. fermenti* 36, *L. casie* and *L. arabinosus* 17/5, respectively. (Gyorgy, 1950; Gupta and Das, 1959; Das *et al.*, 1954).

Methionine, cystine and tryptophane were also estimated microbiologically with the help of *Leuconostoc mesenteroide* P-60 (methionine and cystine) and *Lactobacillus arabinosus* 17/5 (tryptophane) (Gupta and Das, 1955).

RESULTS AND DISCUSSION

Vitamin content

The thiamine, riboflavin and niacin contents of maize as grown under different manurial treatments are given in Table I.

TABLE I. VITAMIN CONTENT OF MAIZE AS AFFECTED BY MANURIAL TREATMENTS

Plot No.	Treatment symbol*	Thiamine		Riboflavin		Niacin	
		Average μg/g	% of control	Average μg/g.	% of control	Average μg/g.	% of control
1A	Control	1·51	100	1·52	100	25·2	100
2A	FYM(A)	1·92	127	1·36	89	25·8	102
3A	FYM(2A)	1·94	128	1·50	98	27·4	108
4A	FYM(A)+RC(a)	1·69	111	1·56	102	28·1	111
5A	RC(2a)	1·33	88	1·53	100	28·7	113
6A	N	1·39	92	1·26	83	27·8	110
7A	K	1·61	106	1·39	91	22·4	89
8A	P	1·93	127	1·49	98	26·2	104
9A	PK	2·26	149	1·38	91	26·6	105
10A	NPK	2·46	162	1·32	87	25·6	101
11A	NP	2·30	152	1·12	74	24·2	96
14A	NK	2·39	158	1·50	98	36·0	142

*FYM(A) —Farmyard manure at 4,000 lb./acre. RC(a)—Rape cake at 20 lb. N/acre
FYM(2A)—Farmyard manure at 8,000 lb./acre. RC(2a)—Rape cake 40 lb. N/acre.
N— Ammonium sulphate at 40 lb. N/acre.
K— Potassium sulphate at 50 lb. K_2O/acre.
P— Superphosphate at 80 lb. P_2O_5/acre.

F.Y.M. seems to have slightly increased the thiamine content of the maize grains while RC shows a reverse tendency.

The thiamine content of maize grains appears to vary considerably with some of the treatments. Application of phosphate appears to show an increase in this constituent. The combinations PK, NP, NK and NPK also seem to have increased this vitamin. Since the combinations have got the effect of individual N or P or K or interaction, the average response due to each has been presented in Table II. Similar observations were made earlier on wheat (Gupta and Das, 1956). Hunt *et al.* (1950) reported that the potash fertilizers decreased the thiamine content of corn while nitrate increased it significantly.

Neither organics nor inorganics, except the NP treatment, appear to have appreciably affected the riboflavin content. The NP treatment has reduced its content to the extent of 26 per cent as compared to the control plot.

The different manurial treatments (organic as well as inorganic) revealed no striking difference in the niacin content except the NK treatment which seems to have increased this constituent by 42 per cent over the control plot.

The average response to N, P and K treatments alone or in combination on the contents of thiamine, riboflavin and niacin, has been worked out by using the general formula:

$$\text{Response} = \frac{(N \pm 1)(P \pm 1)(K \pm 1)}{4}$$

as explained by Yates (1937), wherein the algebraic expression N, P, K and their combinations stand for the numerical values obtained in Table I. In the above equation, 1 refers to the control value.

TABLE II. AVERAGE RESPONSE TO N, P AND K

	Thiamine µg/g.	Riboflavin µg./g	Niacin µg/g.
Main effects			
N	+0·3075	—0·145	+3·30
P	+0·5125	—0·090	—2·20
K	+0·3975	+0·050	+1·80
Interactions			
NP	—0·0225	—0·070	—4·80
NK	+0·1825	+0·170	+3·00
PK	—0·1525	—0·005	—0·90
NPK	—0·2675	—0·015	—2·50

When the main effects of N, P and K individually are seen, it is found that N has shown positive response in the case of thiamine and niacin but negative response in

the case of riboflavin, while P has shown positive response only in the case of thiamine and negative in the other two vitamins. The individual effect of K in all the three vitamins is positive. When the effects of interactions are taken into consideration, it appears to be of interest that NP, PK, and NPK have shown a negative response in all the three vitamins, while NK has given a positive response to all the vitamins studied here.

The apparent increase in the thiamine content due to the different combinations obtained in Table I, may be due to the individual effect of either N or P or K which have all shown positive responses individually. Further, while examining the NP interaction which has shown a very low negative response when compared to the positive response obtained by either N or P, it is difficult to say in the absence of replicated data whether the response due to NP interaction is significant or not, but the low figure indicates that it may not be significant. Thus the overall effect of NP interaction may be negligible. The combination NK which has shown positive response, may prove to be beneficial.

No treatment appears to be beneficial to the riboflavin content, while in the case of niacin, N or K or NK interaction have positive responses. It, therefore, suggests that the NK combination may prove to be useful for niacin.

Amino-acid content

The results showing the influence of various manurial treatments on the methionine, cystine and tryptophane contents of maize grains are presented in Table III.

TABLE III. AMINO-ACID CONTENT OF MAIZE AS AFFECTED BY MANURIAL TREATMENTS

Plot No.	Treatment symbol*	Methionine		Cystine		Tryptophane	
		Average %	% of control	Average %	% of control	Average %	% of control
1A	Control	0·86	100	0·21	100	0·19	100
2A	FYM(A)	0·85	98	0·22	104	0·13	68
3A	FYM(2A)	0·87	101	0·21	100	0·18	95
4A	FYM(A)+RC(a)	0·85	98	0·22	104	0·10	53
5A	RC(2a)	0·85	98	0·24	114	0·17	90
6A	N	0·91	105	0·24	114	0·15	79
7A	K	0·92	106	0·22	104	0·17	90
8A	P	0·97	112	0·24	114	0·07	37
9A	PK	0·88	102	0·21	100	0·16	84
10A	NPK	0·84	97	0·22	104	0·14	73
11A	NP	0·90	104	0·22	104	0·17	90
14A	NK	0·89	103	0·24	114	0·19	100

*FYM(A) — Farmyard manure at 4,000 lb./acre. RC(a)—Rape cake at 20 lb. N/acre.
FYM(2A)— Farmyard manure at 8,000 lb./acre. RC(2a)—Rape cake at 40 lb. N/acre.
N— Ammonium sulphate at 40 lb. N/acre.
K— Potassium sulphate at 50 lb. K_2O/acre.
P— Superphosphate at 80 lb. P_2O_5/acre.

Among the different manurial treatments (organic as well as inorganic), only P treatment appears to show a slight increase in the methonine content, while RC, N, P and NK treatments seem to show a similar tendency with respect to the content of cystine.

F.Y.M.(A), F.Y.M.(A)+RC(a), N, P and NPK treatments appear to have lowered the tryptophane content of the maize grains. Phosphorus alone has lowered the tryptophane content by 63 per cent over the control plot.

The average response to N, P and K treatments or in combination on the contents of methionine, cystine and tryptophane, has been worked out according to Yates (1937) and has been summarized in Table IV.

TABLE IV. AVERAGE RESPONSE TO N, P AND K

	Methionine	Cystine	Tryptophane
Main effects			
N	—0·0225	+0·010	+0·015
P	+0·0025	—0·015	—0·040
K	—0·0275	—0·005	+0·020
Interactions			
NP	—0·0325	—0·015	+0·025
NK	—0·0125	+0·005	—0·015
PK	—0·0475	—0·010	+0·010
NPK	+0·0275	+0·010	—0·045

In the case of the main effects, N has shown positive response to cystine and tryptophane and negative to the methionine content, while the effect of P is opposite to that of N. K individually has given a negative response to the methionine and cystine contents but positive to the tryptophane content. When the effects of interactions are considered, it is found that NP and PK both have shown negative response to the methionine and cystine contents and positive response to the tryptophane content, while NPK interaction has shown the reverse of what NP or PK has shown. NK has shown a negative response to the methionine and tryptophane contents but positive to the cystine content.

The above results are of course only indicative, for objective tests based on statistical analysis could not be made for comparing the effect of different treatments as the experiment was unreplicated.

SUMMARY

This experiment deals with the vitamin (thiamine, riboflavin and niacin) and amino-acid contents (methione, cystine, and tryptophane) of maize grains as influenced by different manures and fertilizers.

F.Y.M. tends to increase while RC a reverse towards the thiamine content of the grains. Application of P has increased the thiamine content, while NP and NK combinations appear to be beneficial for this vitamin.

The riboflavin content is not affected by organic manures. Only N and NP treatments caused a reduction in this constituent.

The niacin content of the grains has been found to be unaffected by organic as well as inorganic treatments except the NK treatment which showed an increase in this constituent.

The methionine content does not appear to be much affected by the organic and inorganic fertilizers except by phosphate which has shown a slight increase in this constituent.

The cystine content appears to be increased by the RC, N and NK treatments.

The tryptophane content appears to be reduced by the F.Y.M., P and NPK treatments.

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STUDIES ON THE NATURE OF CONCRETIONS IN ALLUVIAL SOILS

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CONCRETIONS are of common occurrence in many soils. They are known to be formed as a result of secondary reactions occurring at different depths of a soil profile. These depths are probably governed by both internal and external factors.

The origin of lime nodules had been traced earlier to the capillary rise of soil solution saturated with bicarbonate of calcium from the lower to the upper layers where evaporation of the water during the dry period caused the precipitation of calcium carbonate (Livingstone, 1906; Ramman, 1911). Later workers (Shantz, 1923; Marbut, 1923; Russell and Engle, 1925; Williams, 1931) were of the opinion, however, that the formation of concretions was due to the leaching of $CaCO_3$ in the form of bicarbonates downwards and loss of moisture by evaporation or dessication by plant roots and reduction of the CO_2 pressure, resulting in the decomposition of bicarbonates and precipitation of $CaCO_3$. Gillam (1937) observed that $CaCO_3$ was deposited around quartz, clay or other minerals, and finally got cemented with them during the formation of nodules.

The composition of concretions had been related to the climatic influences the soil was subject to. Singh and Lal (1946) noted that an increase of the N. S. Quotient increased the Fe_2O_3 content of the *kankar*. *Herlenbertz* and *Hoiberg* (1949) observed that while the presence of gypsum indicated a low rainfall, that of Fe, P_2O_5 and Mn showed a high one. The decrease in carbonate, SiO_2 and the increase in Fe indicated that the soils had been subject to a high temperature and high rainfall.

The object of the present investigation was to examine the formation and occurrence of concretions in two alluvial soils—one from Delhi without much $CaCO_3$ in it and other from Pusa which was calcareous in nature—and to throw some light on the interrelationships that existed between the composition of the mother soil and of the concretions which were formed in it.

MATERIAL AND METHODS

The description of the soil profiles and of the concretions occurring in them are given below.

The chemical composition of the soils of the profiles was determined by the fusion method (Piper, 1934). The mechanical analysis of the soils was carried out by the International Method (Robinson, 1933). The determination of the total soluble salts and the soluble cations and anions was made by the methods detailed by Piper (*loc. cit.*). The total base exchange capacity of the soils was determined by ammonium acetate leaching (Schollenberger, 1927) and the exchangeable calcium and magnesium by

leaching with sodium chloride (Hissink, 1923). The exchangeable potassium was estimated by evaporating a known aliquet of ammonium acetate leachate, igniting the residue and extracting the ash with hot water; the potassium was estimated by the cobaltinitrite method (Piper, *loc. cit.*).

Profile I—Top Block, Indian Agricultural Research Institute, New Delhi

Depth (in inches)	Description
0–7	Light brown soil, loamy, single grain structure, loose, penetrated with roots, no effervescence with HCl.
7–13	Light brown soil, darker than above, loose but more clayey, penetrated with roots, effervescence with HCl.
13–41	Light brown soil, compact, single-grain structure, effervescence with HCl.
41–73	Dark brown soil, loamy, single-grain structure, effervescence with HCl.
73–84	Light brown soil mixed with concretions, compact, loamy, brisk effervescence with HCl.
Concretions:	Hard irregular, dull white, large variation in size from a grain to a large ball, powder with difficulty.

Profile II—Botanical Substation Pusa (Bihar)

0–24	Light grey sandy loam, presence of plant roots, brisk effervescence with HCl.
24–42	Light brown sandy loam, scanty roots, occurrence of soft pebbly concretions which can be powdered by hand, brisk effervescence with HCl from a depth of about 30 in. and below.
42–58	Light brown grey sandy loam, structureless, contains hard concretions with yellow mottlings, occurring up to a depth of 78 in.
Concretions:	Somewhat soft, occur throughout a depth of 30-78 in. in the lower layers, possess yellow mottlings.

RESULTS

The composition of the soils of the Delhi Profile and that of the concretions are given in Table I, while that of the soils of the Pusa profile and the concretions are given in Table II.

From the mechanical composition of the Delhi soil profile, it is evident that the soils at different depths are loamy and that there is no definite tendency of the clay to increase or decrease with the depth. It is also seen that the soil at the depth of the occurrence of the concretions has the lowest amount of clay. The *p*H value of the soils increases regularly with the depth, the highest *p*H being observed at the depth where concretions occurred. A characteristic feature of the concretionary layer is the lowest content of exchangeable calcium in proportion to the total base exchange capacity. The salinity of the soils at any depth is not very high except in the soil layer where concretions are observed.

TABLE I. THE COMPOSITION OF THE SOILS OF THE DELHI SOIL PROFILE AND THE CONCRETIONS IN THE PROFILE (OVEN-DRY BASIS)

Constituents	Soil at different depths					
	0-7 in.	7-13 in.	13-41 in.	41-73 in.	73-84 in.	Concretions
Loss on Ignition %	4·04	3·83	4·81	4·34	3·98	4·70
SiO_2 %	79·40	76·27	72·90	69·46	68·12	39·42
Fe_2O_3 %	5·53	7·56	10·05	6·70	5·40	2·64
Al_2O_3 %	5·71	9·62	8·67	13·56	10·71	16·20
CaO %	2·93	1·65	1·82	2·09	6·43	14·29
MgO %	0·77	0·99	1·29	0·66	1·17	0·51
K_2O %	2·87	2·35	2·38	1·93	2·78	1·70
P_2O_5 %	0·21	0·23	0·19	0·15	0·16	0·22
	Mechanical and other analyses					
pH	6·8	6·9	6·9	7·6	7·8	Not determined
Coarse sand %	0·86	0·28	0·43	0·43	1·03	,,
Fine sand %	71·02	71·42	57·88	61·38	74·08	,,
Silt %	13·41	11·40	18·23	10·50	12·23	,,
Clay %	15·30	14·85	21·08	21·38	12·38	,,
Base Exchange capacity m.eq./100 g.	9·70	9·56	13·68	11·80	8·01	,,
Exch. Ca (,,)	6·40	6·00	9·20	10·80	2·30	,,
Exch. Mg. (,,)	2·00	8·40	1·40	2·20	2·90	,,
Exch. K (,,)	0·88	0·93	0·93	0·65	0·30	,,
Total soluble salts %	0·146	0·120	0·096	0·112	0·160	,,
NO_3 % (in total soluble salts)	0·0020	0·0018	0·0018	0·0018	0·0013	,,
CO_3 % (,,)	Trace	Trace	Trace	Trace	Trace	,,
HCO_3 % (,,)	0·0397	0·0305	0·0305	0·0366	0·0549	,,
SO_4 % (,,)	Trace	Trace	Trace	Trace	Trace	,,
Cl % (,,)	0·0035	0·0071	0·0053	0·0053	0·0018	,,
CaO % (,,)	0·0120	0·0086	0·0073	0·0086	0·0093	,,
MgO % (,,)	0·0038	0·0030	0·0028	0·0026	0·0026	,,
K_2O % (,,)	0·0044	0·0049	0·0046	0·0047	0·0039	,,

TABLE II. COMPOSITION OF THE SOIL AND OF THE CONCRETIONS OCCURRING IN THE PUSA PROFILE (OVEN-DRY BASIS)

Constituents	Soil at different depths profile 0–24 in.	24-42 in.	42-54 in.	Concretion
Loss on Ignition %	10·90	12·63	19·51	15·73
SiO_2 %	44·73	42·13	37·60	29·48
Fe_2O_3 %	7·74	3·86	3·18	4·39
Al_2O_3 %	4·30	7·52	10·53	5·67
CaO %	18·66	21·96	23·25	32·90
MgO %	1·37	1·29	1·95	1·71
K_2O %	1·64	1·32	1·16	3·27
P_2O_5 %	0·17	0·16	0·16	0·20
Mechanical and other analyses				
*p*H	8·8	8·9	9·2	Not determined
Coarse sand %	Trace	Trace	Trace	,,
Fine sand %	35·72	42·46	40·53	,,
Silt %	16·38	16·86	14·09	,,
Clay %	17·17	4·74	6·28	,,
Base Exch. Capacity (m.eq./100 gm.)	3·40	4·00	4·70	,,
Exch. Ca (,,)	2·00	3·50	3·80	,,
Exch. Mg. (,,)	0·64	0·35	0·35	,,
Exch. K. (,,)	0·75	0·66	0·61	,,
Total soluble salts	0·1090	0·1180	0·1250	,,
NO_3 % (in total soluble salts)	0·0017	0·0011	0·0014	,,
CO_3 % (,,)	Trace	Trace	Trace	,,
HCO_3 % (,,)	0·0732	0·0610	0·0610	,,
Cl % (,,)	0·0142	0·0142	0·0159	,,
SO_4 % (,,)	Trace	Trace	Trace	,,
CaO % (,,)	0·0210	0·0131	0·0133	,,
MgO % (,,)	0·0060	0·0072	0·0057	,,
K_2O % (,,)	0·0048	0·0054	0·0052	,,

As is apparent from their $CaCO_3$ content, the soils of the Pusa profile are calcareous in nature, the clay content is the highest at the surface though it decreases in the second layer and again increases in the concretional layer. The base exchange capacity of the soils increases with the depth. The salt contents of the soils are high. Among the anions, the bicarbonate decreases with the depth and is the lowest at the depth of occurrence of the concretions. It is evident that the loss in ignition value increases with the depth and is the highest at the depth of occurrence of the concretions. The SiO_2 content decreases with the depth, being lowest at the depth of the occurrence of the concretions, Fe_2O_3 decreases while Al_2O_3 increases with the depth. At the depth of occurrence of the concretions, Fe_2O_3 is the lowest while Al_2O_3 is the highest. The sesquioxides are the maximum at this depth. CaO and MgO increase with the depth while P_2O_5 shows the tendency to decrease with the depth, though the decrease is not very significant.

The composition of the concretions in the soils shows that they are calcareous, and the lime content of the concretions from the Delhi soils is lower than that of the concretions from the Pusa soil. The former are observed to be harder as compared to the latter. This may have been due to the cementing action of the sesquioxides which are higher in the concretions from the Delhi soil, than in those from the Pusa soil. The Fe_2O_3 content of the concretions from the former is higher than concretions from the Pusa soils due to the more rainfall received at Pusa (Singh and Lal, *loc. cit.*). The source of lime of the concretions from the Delhi soil appears to be the calcium-bearing minerals.

The soils of the Pusa profile are calcareous and it is due to this that the total of mechanical fractions is below 100, as the lime gets decomposed by the acid treatment at the time of the mechanical analyses. The source of lime in the concretions must have been the large excesses of the $CaCO_3$ present in the soil. The process of lime nodule formation, may not, therefore, be the same as in the case of the Delhi soil. The difference in the composition of the concretions and the mother soil at Delhi is quite marked, while it is not so in the case of concretions and the mother soil from Pusa. The extra $CaCO_3$ may necessarily cause a lowering in the percentage of SiO_2, etc., in the cemented particles, i.e., the concretions.

Information regarding the formation of these concretions at a particular depth is not definite, but it is possible that a depth with a lower clay content precipitates lime due to the lowering of the CO_2 pressure or the rise of the sub-soil water rich in carbonates which interact with soluble calcium salts at a particular depth—the depth of the penetration of soil moisture. A more sandy layer facilitates dessication and release of CO_2, and thus creates conditions favourable for the precipitation of $CaCO_3$ and the formation of concretions.

SUMMARY

A study of two alluvial soils—one from a semi arid region (Delhi) and another from a humid area (Pusa)—and of the concretions occurring in these profiles was made during the present investigation. The concretions in both the soils were found to be calcareous.

The concretions in the Delhi soil occurred at a depth of 73-84 in. and were quite hard. They had a large content of sesquioxides. The occurrence of the concretions was restricted to a layer of the soil with a high *p*H and high alkalinity.

The concretions in the Pusa soil occurred at a depth of 30-78 in. and were soft. There was a large variation in the size of the concretions. At the lower depths they were charactized by yellow mottlings. The soil layer bearing concretions had high alkalinity.

The probable mode of the formation of the concretions in the soils has been discussed.

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BIONOMICS OF *PHYLLOTRETA CRUCIFERAE* GOEZE (COLEOPTERA; CHRYSOMELIDAE)

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Species of the genus *Phyllotreta* are commonly known as flea beetles, and out of the 24 species, recorded as feeding on Cruciferae, those causing considerable damage to cabbage, turnip, radish and beet, are: *P. cruciferae* Goeze, *P. nemorum* L., *P. atra* Payk, *P. nigripes* F., *P. undulata* Kutsch, *P. consobrina* Curt, *P. variipennis* Boield, in almost all the European countries including Russia (Newton, 1928; Pyatakova, 1928; Domingues, 1946); *P. aerea* Allard, *P. striolata* F., *P. pusilla* Horn., *P. albionica* Lec., *P. oregonensis* Crotch, *P. utana* Chitt., *P. zimmermanni* Crotch, *P. liebecki* Schaffer, *P. aenicollis* Crotch and *P. bipustulata* F., in North and South America (Frost, 1949), *P. australis* Blkb., in Australia; and *P. vittata* (*striolata*) Fabr., in Japan (Harukawa and Tokunaga, 1938). Flea beetles have also been recorded as vectors of plant diseases by Smith and Markham (1946) who have reported *P. cruciferae* and *P. vittula* transmitting turnip yellow mosaic virus in Great Britain.

In India, four species, viz., *P. birmanica* Harold, *P. oncera* Maulik, *P. chotanica* Duviv. and *P. downesi* Baly, were recorded by Maulik (1926). *P. cruciferae* was later recorded damaging *Brassica* crops during surveys carried out by the Indian Agricultural Research Institute, New Delhi, from time to time. Banerji and Basu (1954) reported damage from *P. chotanica* to mustard crop in West Bengal. Narayanan (1958) also described *P. cruciferae* as pest of rape and mustard in India. In spite of the serious nature of the injury that *P. cruciferae* inflicts on cultivated cruciferous plants, its biology has hitherto remained unstudied. The present paper puts on record some observations made on the bionomics of this species as observed in Uttar Pradesh in India during 1950-53.

MATERIAL AND METHODS

Rearing of adult beetles was carried out in small beakers and jars on young radish plants. The egg count was done by the floatation method. The upper layer of the soil was dispersed in water and the eggs, which floated on the surface, were counted. The first stage larvae were collected by washing the roots, while for studying the second and third stage larvae, roots were teased and the larvae isolated. The pupal cells were collected by sieving the soil. Permanent slides of eggs, larvae and pupae were prepared.

Life-history

Pre-copulation and pre-oviposition periods: The male and female beetles copulate two to four days after emergence from pupae and egg-laying follows within 24 to 48 hours after the first copulation.

Egg: The eggs are creamy white in colour, elongated, suboval, 0·3 to 0·35 mm. long and about half as broad. They are mostly laid singly, but sometimes in batches of two to three, in the soil around the host plants.

During the life-time of one and a half to two months, a female beetle lays 50 to 80 eggs in as many number of times or less, depending on the number of eggs laid each time during a period of 25 to 30 days. The incubation period ranges between five to ten days.

Larva: The freshly hatched larva is milky white in colour, 0·3 mm. in length, and the body parts are hardly differentiable, and immobile. It becomes active only a few hours after hatching.

The larva at the first stage is dirty white in colour with pale yellow head and measures about 0·5 mm. in length and 0·2 mm. in breadth. The chitinous areas on the thorax and abdomen are not fully defined at this stage. The larva is very active and feeds on the tender roots of the host plant. The duration of the first larval stage is from three to four days.

At the second stage, it turns creamy white in colour, the head being light brown. The body can be differentiated into distinct thoracic and abdominal segments, which become defined by the presence of faint chitinized plates. It measures 2 mm. in length and 0·5 mm. in breadth. The larva mines into the roots of the host plant and further growth takes place inside the tunnel bored by the larva. The period of second stage larva ranges between three to five days.

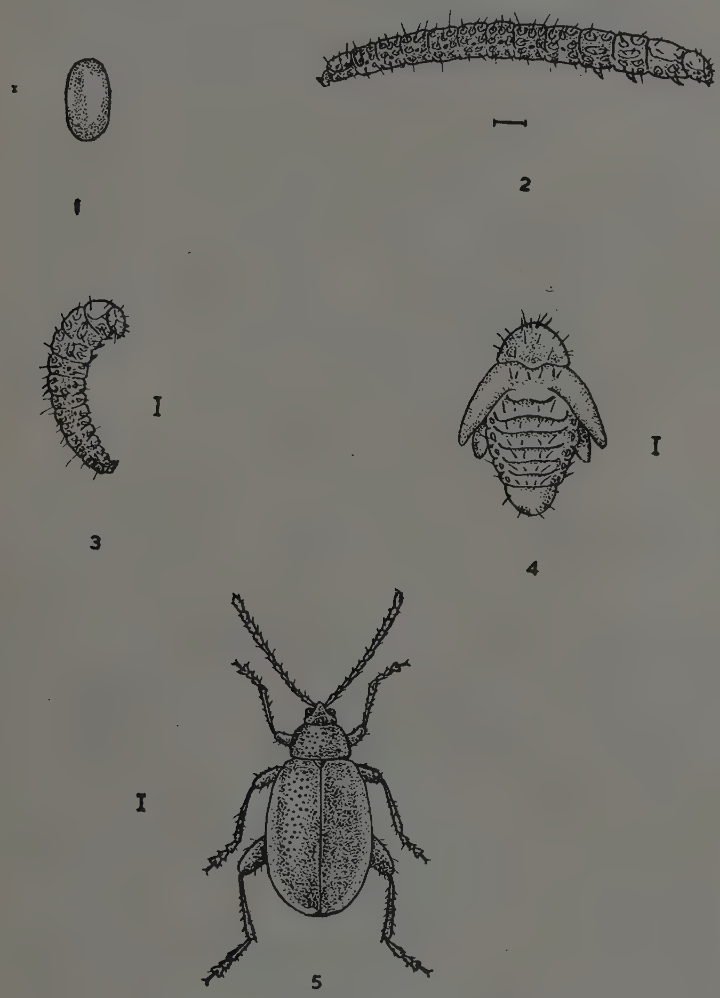
The full-grown at the third stage larva is cruciform in shape, pale white in colour and measures 4·8 to 5 mm. in length and 0·5 to 0·6 mm. in breadth. The head is strongly chitinized and oval in shape, while the thorax and abdomen bear chitinized plates arranged in the following manner. The prothorax bears a large dorsal, a pleural, a pair of subventral, ventral and mid-ventral chitinized plates, while the meso- and metathorax possess a mid-antero-dorsal, a postero-dorsal, a long sub-dorsal, a pair of small pleural, subventral and ventral chitinized plates, respectively. The abdominal segments, except the eighth and ninth, bear chitinized plates arranged in three rows. There are three small antero-dorsal, a mid-dorsal, a small postero-dorsal, a pleural, a subventral, an antero-ventral and a pair of postero-ventral chitinized plates. In the eighth segment, the arrangement of plates is similar to that in the preceding segments except for the presence of a large mid-postero-dorsal plate, while the ninth segment is completely chitinized dorsally. The tenth segment is small and feebly chitinized. The chitinized plates are provided with small minute setae and pores. The larval legs are short and four-segmented.

Before entering the pupal stage, the larva becomes immobile and shortens in length, with the result that it increases in width and assumes an arcuate appearance. The third larval stage lasts from three to six days.

The larva moults thrice before pupation, during a total larval period of nine to fifteen days.

Prepupa: The larva before entering into the prepupal stage wriggles out of the mined roots and prepares an earthen cell 0·5 mm. long and 3 mm. broad, in the vicinity of the infested root for pupation. The prepupa is small and assumes a semiarcuate appearance, measuring 2·8 mm. in length and 0·4 mm. in breadth near the thoracic

region. It is dirty pale in colour with the head slightly curved ventrally. The thoracic region is broad with the legs retracted beneath, while the abdominal segments gradually taper distally. The prepupal stage lasts for two to four days.



THE FIVE STAGES OF *P. cruciferae* GOEZE
1. EGG 2. LARVA 3. PREPUPA 4. PUPA 5. ADULT

Pupa: The young pupa is whitish in colour, turning pale yellow when mature, and measures 2·2 mm. in length and 1 mm. in breadth. The anterior margin of the

prothorax is beset with dark fine hairs which are sparsely distributed all over the thoracic and abdominal segments. The antennae are situated ventro-laterally and extend posteriorly up to the second abdominal segment. They are concealed under the folded legs in the middle. The legs are arranged in their respective thoracic segments with tarsi placed mid-longitudinally. The elytra and wing pads develop laterally below the prothorax and extend up to the second abdominal segment. The ventral surface of the pupa is exposed and provided with fine, minute hairs.

Before the emergence of the imago, the colour of the pupal eyes, mandibles, antennae, elytra and femur changes to brown or brownish black. The pupal period lasts for about eight to fourteen days.

Adult: The dorsum of the adult is metallic blue in colour, with a greenish tint. The ventral side is piceous. The body is elongated, narrow in front but gradually broadens distally and is round at the apex. The head is finely punctate, the dorsal surface slightly convex, eyes convex and small and the antennae extend beyond the middle of elytra. The pronotum and elytra are strongly and uniformly punctate. The ventral side of the adult is impunctate and covered with fine, minute whitish hairs. The tibia of each hind leg bears an apical spine, and the first tarsus is as long as the first and second tarsi of the middle and fore legs.

Female beetle	2 mm. long	1 mm. broad.
Male beetle	1·8 mm. long	0·9 mm. broad.

Seasonal history

P. cruciferae was present in the fields and nursery plots throughout the year safe in the cold months of November, December and January, when the adults hibernate in the soil or plant debris. It seems to prefer warm climatic conditions for breeding in the plains of Uttar Pradesh. In the present observation it was noticed that there was an abrupt increase in its population in the fields in the month of April, May and June. The overwintered adults emerged with the approaching warm climatic conditions in the last week of February or beginning of March and settled on mustard, *toria*, *rai*, *taramira*, turnip, radish or pea crops, seldom appearing in large numbers on cabbage, cauliflower or knol khol. Serious damage to cabbage became manifest late in March or April, when practically all the leaves in the head were attacked and rendered unfit for consumption. The injury consisted of small holes eaten through or into the leaf. In the hot months of May and June, the beetles migrated to radish plots and when not controlled, the whole crop suffered severe loss. Often, the damage done to nursery plots of turnip warrants the grower to resow them. The pest seems to thrive better on cruciferous plants that grow in the fields either in a wild state or under cultivation in the months of July, August and September, migrating to young mustard or *toria* or *taramira* crop in October, on which it feeds till the time of hibernation.

There are seven to eight generations of *P. cruciferae* in a year.

Food plant: Almost all the cruciferous plants are attacked by this pest. The oilseed crops like mustard, *rai*, *taramira*, *toria* and vegetables like radish, turnip, cabbage, cauliflower and knol khol are severely damaged. Peas are often attacked but without any appreciable damage to the crop. Some winter flowering plants, viz.,

dahlia, Sweet Sultan and antirrhinum have also been observed to provide food for the beetles.

The adults mostly feed on the leaves by making innumerable round holes in them. The stem, flowers and even pods may be attacked. The old, eaten away leaves dry up while the young leaves are rendered unfit for consumption. A special kind of decaying odour is emitted by cabbage plants attacked by *Phyllotreta* spp., and such odour is rarely encountered in other host plants.

CONTROL

The pest is recommended to be effectively controlled by dusting the crop with five per cent BHC (Narayanan, 1958), at the rate of 15 to 20 lb. per acre should it occur on non-vegetable crops. On vegetable crops spraying with 0·25 per cent DDT (*Plant Protection Bulletin—Pests and Diseases Number*, 1955) at the rate of 60 to 80 gallons per acre or dusting with five per cent DDT at the same rate as BHC should be done at an early stage. On leafy vegetables, pyrethrum insecticides should be used in the strength of 0·003 per cent as spray or three per cent as dust at the rate of 60 to 80 gallons and 15 to 20 lb. per acre, respectively.

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THINNING OF PLUMS*

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THE temperate fruits are prone to bear much more crops than can normally be carried to maturity. Large quantities, therefore, fall off in series of waves after the set. In spite of this heavy natural drop, the amount left on the trees is often so large that the size and quality of fruit remain inferior if thinning of fruits is not practised.

Thinning of plums has been practised by numerous workers. The results of experiments carried out by Farrend (1903), Painter *et al.* (1928), Waring (1931), Dickson (1931-32), Levitt (1946) and Ward (1952) showed that the thinning of plum varieties, which tend to overload, was undoubtedly beneficial to the tree and fruit. The size and weight of individual fruits increased in proportion to the thinning. Fruits from heavily thinned trees matured earlier than from lightly thinned ones. Thinning increased the trunk surface, shoot length and shoot diameter. Whether thinning is profitable depends upon the price offered for the larger fruit and the reduction in brown rot which spreads more rapidly when the fruits touch each other. Thus, apart from regular pruning, spraying and manuring, thinning of fruits has become an important orchard operation.

Planned investigations into the problem of thinning of plums have not been reported in this country except for the solitary instance of such work having been done at Coonoor in the Nilgiris (Naik, 1948). The results reported from Coonoor, however, justify extended trials of fruit thinning with all the commercial varieties grown in the country.

Of the plum varieties growing at the Fruit Research Station, Kandaghat, Simla Hills, it was found that Santa Rosa, Beauty and Mariposa were particularly more prolific than others. The crops borne are considered to be of inferior quality and, because of this, the growers do not get good economic returns. The object of the present investigation was, therefore, to determine the optimum load of fruit that could be permitted to remain on plum trees of Beauty and Santa Rosa for obtaining commercial crops of good quality. Therefore, different intensities of thinning were employed to study their effect on the size and quality of fruit.

MATERIAL AND METHODS

Fruit thinning is practised either at the blossoming time with the help of chemicals or with the hands after the fruit has set. Hand-thinning was employed in the present investigations in order that the results, if found promising, could be readily adopted. Hand-thinning also helps in exercising a better control over the thinning operations

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in that the right type of fruit is retained which is not possible by other methods. Hand-thinning also avoids physical injury to the fruit left on the trees. The operation was performed from April 8 to 10, 1957, in the case of the Santa Rosa variety and April 15 to 17, 1957, in the case of Beauty. In both the varieties, thinning was done nearly four weeks after the full bloom. In light thinning, one-third of the number of fruits was removed, whereas in heavy thinning the number of fruits removed amounted to one-half. The following records were taken during the years 1956-58.

Growth measurements of selected limbs

The growth measurements of selected limbs were taken in December, 1956, at the time of selection of material, and again in December, 1957, after the thinning trials were carried out. The measurements were made with a flexible steel tape graduated in millimetres.

Measurement of total annual shoot growth

Measurements of individual shoot growths were made on each branch in turn. These measurements were made by working them from the tip of the limb downwards or from the base upwards; the latter method being less confusing was the one adopted in these investigations. As each branch was measured, it was marked with chalk in order to prevent repetition.

Measurement of leaf-area

The total number of leaves on the limbs under the various thinning treatments was counted. The leaf-area of 100 leaves, taken at random on each limb, was measured by the use of an integrator described by Vyvyan and Evans (1932). The total leaf-area on a limb was worked out by multiplying the average leaf-area by the total number of leaves borne by it. The leaf-area per fruit was arrived at by dividing the total leaf-area by the number of fruits borne.

Average weight per fruit

The weight per fruit was worked out by dividing the total weight of 100 representative fruits from each treatment.

Size of fruit

The size of fruit was determined in two ways: firstly, by counting the number of fruits in one lb.-weight, and, secondly, by the 'water displacement' method. To determine the size by the water displacement method, 100 fruits were taken at random separately from each thinning treatment. The total quantity of water displaced by 100 fruits from each experimental lot was separately measured with the help of a graduated cylinder. The volume (size) per fruit was worked out by dividing the volume of water displaced by 100 fruits.

Yield records

At the time of each picking, the quantity of fruit picked was weighed. The yield data from each and every limb were recorded separately on each occasion.

Finally, when the crop was completely picked, the total yield from each limb was worked out. The fruit used for analytical and other purposes was also weighed and accounted for in the total yield.

Pulp-stone ratio

Six fruits from each treatment were taken at random and their weight recorded. The pulp and stones were then separated. The stones were thoroughly washed and all the sticking pulp removed before they were weighed. The pulp-weight was worked out by subtracting the weight of the seeds from the weight of the whole fruit. The weights were recorded in grams for working out the pulp-stone ratio separately for all the treatments and replications.

Acidity in fruit pulp

Six fruits of uniform maturity at the optimum stage of ripeness were selected by visual judgment. The juice was extracted from these fruits by squeezing them with the hands. Out of the clear juice obtained, 5 c.c. of it was taken and titrated against N/10 NaOH solution, using phenolphatheline as the indicator. The percentage of acidity was calculated in terms of anhydrous citric acid.

Total soluble solids in juice

The total soluble solids in the juice were determined with the help of a hand refractometer and corrected at 68°F. The instrument was washed with distilled water and perfectly dried before taking the next reading.

Organo-leptic tests

The organo-leptic tests were made by a panel of judges on a score-card basis according to which 25 per cent marks were assigned to the appearance of fruit, 25 per cent to colour intensity, 25 per cent to taste and 25 per cent to aroma. All the three judges allotted marks on the basis of the score-card separately for each treatment and replication.

Statistical methods employed

The observational data for the various characters studied, viz., yield, size of fruit, shoot length, etc., were statistically analysed by the analysis of variance method after Fisher (1934). The eight trees of each of the two varieties under study were taken as ' blocks '.

RESULTS

Effect upon the amount of crop produced

The yield data in respect of both the varieties under the different treatments of thinning are set out in Table I.

TABLE I. THE MEAN YIELD IN OZ. PER LIMB

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D. at 5%	Results
Santa Rosa	443	405	408	±19·86	60·25	A CB
Beauty	865	838	830	± 5·28	16·01	A BC

It is clear from the data that in Santa Rosa the unthinned limbs gave more yield than the thinned ones. The reduction in yield brought about by the thinning treatments was not, however, statistically significant. Thus, both the treatments of thinning did not significantly reduce the yield in Santa Rosa as compared to no-thinning. On the contrary, the yield in Beauty was significantly reduced by both the thinning treatments as compared to no-thinning. However, here again the influence of thinning treatments upon the yield was almost identical as the differences were not statistically significant.

The data in Table I also bring out the fact that the yield in Beauty is almost twice the outturn in Santa Rosa. Thus, it is probable that it is only in respect of very heavy-bearing varieties that thinning treatments significantly reduce yields as compared to no-thinning.

Effect upon the size of fruit

The effect of thinning upon the fruit-size was studied in two ways: firstly, by counting the number of fruits per pound from the various thinning treatments, and, secondly, by the water displacement method giving the volume in cubic centimetres per fruit. The results from both these studies are compiled in Tables II and III.

TABLE II. NUMBER OF FRUITS PER LB.

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	12·9	10·0	7·6	±0·597	1·81	A B C
Beauty	53·8	30·6	20·6	±2·48	7·52	A B C

TABLE III. VOLUME IN CUBIC CENTIMETRES PER FRUIT

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	34·7	38·6	45·2	±1·29	3·91	C B A
Beauty	8·2	13·4	19·5	±0·75	2·27	C B A

The data in Table II show that in both the varieties under study both the thinning treatments resulted in increased size of fruit as compared with no-thinning and

the size of fruit was increased in proportion to the severity of thinning practised (Plate I). All these differences were statistically significant.

Top row: Santa Rosa Plum
From Left to Right: ½ thinning, ⅓rd thinning, control

Bottom row: Beauty Plum
From Left to Right: ½ thinning, ⅓rd thinning, control

Referring to the data in Table III, it would be seen that the volume of fruit under both the thinning treatments for both the varieties under study was significantly more as compared with no-thinning. Of the two thinning treatments, heavy thinning significantly increased the size of fruit in comparison with the light one.

These results clearly bring out the fact that thinning would invariably increase the fruit-size. But to obtain extra large size of fruit in plums, heavy thinning would be better than a light one. However, in heavy-bearing varieties, both the treatments are likely to prove useful for increasing the fruit-size.

Effect upon the average weight of fruit

The data on the average weight of fruit under the various thinning treatments are set out in Table IV.

TABLE IV. THE AVERAGE WEIGHT OF FRUIT IN OZ.

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	1·35	1·50	1·90	±0·069	0·21	$\overline{A\ B}\ C$
Beauty	0·31	0·48	0·75	±0·028	0·08	A B C

The mean weight figures show that the thinning treatments increased the weight per fruit in both the varieties under study. All the differences were statistically significant except the increase in weight brought about by the light thinning treatment over no-thinning in Santa Rosa. The results are particularly more interesting in the case of Beauty, a very heavy-bearing variety.

Effect upon the pulp-stone ratio

With a view to determining whether the increase in fruit-size brought about by the thinning treatments was due more to the increase in the amount of pulp or the weight of stone, the data for the pulp-stone ratio and weight of stone were worked out and are shown in Tables V and VI.

TABLE V. THE PULP-STONE RATIO

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	33·97	35·74	39·95	±1·33	4·03	$\overline{A\ B}\ C$
Beauty	13·15	15·35	18·68	±0·84	2·55	A B C

TABLE VI. THE WEIGHT PER STONE IN GRAMS

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	1·2	1·4	1·5	±0·08	0·26	$\underline{A\ \overline{B}}\,\overline{C}$
Beauty	0·78	0·85	1·15	±0·146	0·44	$\overline{A\ B}\ C$

It would be seen from the data in Table V that the pulp-stone ratio increased with the severity of thinning. Comparing the pulp-stone values, it would be noticed that there was no significant difference between the control and light-thinned limbs. The heavy-thinned limbs, on the other hand, registered a significant increase in the pulp-stone ratio not only over the control limbs but also over the light-thinned limbs. These results obtained for both the varieties are identical and clearly show that the increase in fruit-size resulted from a significant increase in the amount of the pulp-stone ratio

rather than the weight of stones. All the same, the percentage of increase was much more in Beauty than in Santa Rosa.

To ascertain as to how far the weight of stone increased along with the size of the fruit, data collected on the weight per stone from different treatments are set out in Table VI. It would be seen from these data that the treatment differences are extremely small and are not statistically significant when compared with the critical difference in both the varieties, except that in Santa Rosa heavy thinning registered a significant increase in the mean weight of stone over no-thinning. On the whole, therefore, these data lend support to the conclusion that the increase in weight and size of fruit resulting from the thinning treatments was mainly due to the increase in the amount of pulp rather than the increase in the weight of stone.

Effect upon the total soluble solids (sugars) in the juice

The data for total soluble solids in the juice of fruit from the various thinning treatments corrected at 68° F are set out in Table VII.

TABLE VII. THE TOTAL SOLUBLE SOLIDS CORRECTED AT 68° F

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	15·20	15·65	16·53	±0·42	1·27	$\overline{A}\,\underline{B\,C}$
Beauty	12·43	13·15	13·88	±0·185	0·56	A B C

The data in Table VII would show that in the case of Santa Rosa, heavy thinning significantly increased the total soluble solids in the juice as compared to no-thinning, but the difference was not quite significant between the light-thinned and heavy-thinned limbs. Light thinning also did not significantly increase the total soluble solids over no-thinning. In Beauty, on the contrary, both the thinning treatments significantly increased the total soluble solids as compared to no-thinning. Furthermore, heavy thinning significantly increased the total soluble solids as compared to light thinning. The thinning had, therefore, not only increased the size of fruit, as shown previously, but also significantly increased the sugar content of the juice, thereby improving considerably the quality of fruit and its market value.

Effect upon the acidity of fruit

The data for the acid content of juice are set out in Table VIII.

TABLE VIII. THE ACIDITY OF FRUIT

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	1·32	1·11	0·97	±0·029	0·09	A B C
Beauty	2·21	2·14	1·49	±0·075	0·23	$\overline{A\,B}$ C

Comparing the data for acidity with the critical difference in Santa Rosa, it would be seen that both the thinning treatments significantly reduced the acidity in comparison with no-thinning. Furthermore, the heavy thinning treatment resulted in further reducing the acid content as compared to light thinning, and this difference between the two thinning treatments was statistically significant.

In the case of Beauty, light thinning did not produce any significant reduction in fruit acidity as compared with no-thinning, but heavy thinning significantly decreased acidity as compared to no-thinning as well as the light thinning treatment.

The thinning treatments reduced the acidity of the fruit in both the plum varieties under study. Heavy thinning significantly reduced the acidity not only as compared to no-thinning but also the light thinning treatment.

Effect upon the T.S.S./Acid ratio

The effect of thinning upon the total soluble solids and acidity of the fruit separately, does not bring out its effect on the blend or taste of the fruit. This can best be studied by the T.S.S./Acid ratio. This ratio takes into account both the components of the juice, namely, acidity and sugars or the blend which is a better criterion for the study of quality of fruit as affected by thinning. Accordingly, the T.S.S./Acid ratios were worked out from the data on the T.S.S. and acidity, and are set out in Table IX.

TABLE IX. THE T.S.S./ACID RATIO

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	12·7	16·4	21·3	±1·31	3·96	A B C
Beauty	5·8	6·3	10·0	±0·50	1·51	$\overline{\text{A B}}$ C

It would be seen from the data in Table IX that in both the varieties under study, heavy thinning significantly improved the blend or taste of the fruit as compared to light thinning and no-thinning. Light thinning, on the other hand, improved the taste of the fruit only slightly as the differences over no-thinning were not statistically significant.

Effect upon the vigour of limbs

To study the effect of thinning on the vigour of limbs, data for the girth and total shoot growth were recorded after subjecting the limbs to thinning treatments. These data are set out in Tables X and XI.

TABLE X. THE GIRTH OF LIMBS IN CM. IN WINTER 1957-58

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	21·8	22·9	23·6	±0·24	0·72	A $\overline{\text{B C}}$
Beauty	23·8	25·2	25·7	±0·34	1·03	A $\overline{\text{B C}}$

TABLE XI. THE TOTAL SHOOT LENGTH IN METRES IN WINTER 1957-58

Variety	A: No thinning	B: Light thinning	C: Heavy thinning	S.E.	C.D.	Results
Santa Rosa	29·9	33·8	30·4	±2·29	6·95	A B C
Beauty	26·1	26·4	31·4	±2·79	8·47	A C B

The data in Table X would show that in both the varieties under study, the girth of limbs significantly increased under both the thinning treatments as compared with the limbs under no-thinning. However, there was no significant difference in the girth of limbs under light and heavy thinning, although in Santa Rosa the increase in girth under heavy thinning was much more than in Beauty. It is clear that the limbs under the thinning treatments made significantly more growth in comparison with limbs where no thinning was done. Therefore, to maintain the vigour of trees, thinning of fruit appears to be an essential orchard practice.

From the data in Table XI it would be seen that the shoot length was more on limbs under the thinning treatments as compared to those under no-thinning, but the differences were not statistically significant. These results are identical for both the varieties under study, the only difference being that in Santa Rosa the average shoot length was in favour of light thinning, whereas in Beauty the shoot length was the greatest in the case of heavy thinning.

Considering the results of girth and shoot length together for both the varieties, it is evident that the thinning of fruit is necessary to maintain the vigour of these plum varieties. Since the girth measurement is known to be a much better index of vigour as compared to other growth indices like shoot length, height, spread and tree volume, the data in respect of girth reported here clearly show the outstanding effect of fruit thinning for maintaining tree vigour.

Effect upon the number of leaves and leaf-area in sq. cm. per fruit

After subjecting the selected limbs to the thinning treatments, the number of leaves on each limb was separately counted and the leaf-area per fruit was worked out. The data have been set out in Table XII.

TABLE XII. THE NUMBER OF LEAVES AND LEAF-AREA IN SQ. CM. PER FRUIT

Variety	A: No thinning		B: Light thinning		C: Heavy thinning		S.E.	C.D.	Results
	No. of leaves	Leaf-area	No. of leaves	Leaf-area	No. of leaves	Leaf-area	Per leaf-area	Per leaf-area	
Santa Rosa	62·7	766	87·4	1,157	11·0	1,453	±108	327	A B C
Beauty	4·7	48·19	7·6	65·75	12·6	125·46	±11·73	35·57	A B C

The number of leaves per fruit in both the varieties increased with the severity of thinning. This could naturally be expected. The leaf-area per fruit also increased. Since the leaf-area per fruit is a better criterion than the number of leaves for the purpose of comparing the effects of thinning, the statistical constants were calculated for leaf-area only. Comparing the leaf-area figures under the different treatments in Santa Rosa with the critical difference, it would be seen that both the thinning treatments resulted in a significant increase in the leaf-area per fruit over no-thinning. Heavy thinning also registered considerable increase in the leaf-area as compared with light thinning, but the difference was not statistically significant. In Beauty also, the thinning treatments resulted in increased leaf-area per fruit as compared to no-thinning, but the difference was statistically significant only in the case of heavy thinning. Between the two thinning treatments, heavy thinning significantly increased the leaf-area per fruit as compared to light thinning.

Considering these results together for both the varieties, it is clear that higher leaf-surface per fruit on the limbs under thinning treatments may be regarded as directly responsible for increasing the size of fruit and improving its quality.

Further examination of the data in Table XII would reveal that the number of leaves per fruit in Santa Rosa was nine to 12 times more than that in Beauty. Similarly, the leaf-area per fruit in Santa Rosa was 11 to 15 times the leaf-area under corresponding treatments in Beauty. This could perhaps be expected because of the comparatively much heavier cropping in Beauty. From the evidence accumulated, the point worth noting is that to get fruit of extra large size and of excellent quality, the number of leaves per fruit in the case of Santa Rosa should be approximately 111, but 13 leaves per fruit in the case of Beauty is considered inadequate despite the fact that the size and quality of fruit were considerably improved. Further work involving more severe thinning in Beauty appears to be necessary to enhance further the size and quality of fruit of this variety.

The quality of fruit as judged by organo-leptic tests

The quality of fruit was adjudged by a panel of judges on the basis of a score-card. This study was made particularly to assess the effects of thinning on colour development and aroma of fruit. The mean marks awarded by judges are compiled.

TABLE XIII. THE QUALITY OF FRUIT BY ORGANO-LEPTIC TESTS

Variety	A: No thinning	B: Light thinning	C: Heavy thinning
Santa Rosa	41	50·9	60
Beauty	39·9	50·2	60

The data show that the percentage of marks for the various treatments was progressively higher in proportion to the severity of thinning for both the varieties under study. The figures being so consistently high under the thinning treatments,

no attempt has been made to analyse the data statistically. It can, however, be safely concluded that the quality of fruit, as judged by the organo-leptic tests, was far superior under the thinning treatments as compared to no-thinning. It was also noted that the intensity of colour development under heavy thinning was distinctly better than that under other treatments, and the fruit under this lot could be readily distinguished from others on this basis.

DISCUSSION

The size of fruit increased in proportion to the severity of thinning in both the varieties under trial. The average weight of fruit, which is an index of size, was also significantly increased by heavy thinning. It is further established by these results that the increase in the fruit-size or its average weight resulted from a significant increase in the amount of pulp rather than the weight of stone. These results corroborate the findings of Levitt (1946) who worked on the thinning of Japanese plums in New South Wales, Australia. Ward (1952) also reported outstanding increase in the size of Japanese plums by thinning. Other workers such as Farrand (1903), Waring (1931), Painter and Wates (1928) and Dickson (1931-32), working independently with European plums in England and America, reported that thinning improved the size of fruit.

The sugar content of fruit was significantly improved by thinning. These results are in accord with the findings of a number of workers employing different kinds of fruits. The acidity of fruit progressively decreased with the severity of thinning. The decrease in acidity could be expected in view of the significant increase in the T.S.S. of juice resulting from thinning. It could also be partly ascribed to the advance in maturity brought about by thinning (Painter and Wates, 1928). Further, the T.S.S./Acid ratio or the taste of fruit was considerably improved by thinning. The fruit under the thinning treatments was found to be far superior in colour development and aroma to that under no-thinning. In fact, the fruit under heavy thinning could be readily distinguished from other lots on the criterion of colour development alone. Thus, the thinning of fruit favourably influenced all attributes of quality.

The higher leaf-area per fruit under the thinning treatments could be regarded as directly responsible for increasing the fruit-size and improving its quality. Sufficient evidence is available in literature to show that with an increase in the leaf-area per fruit the size of fruit increases and its quality improves. The increase in the number of leaves is not, however, the same in the case of different kinds of fruits or the varieties of the same fruit. Even in these investigations, the requirement of leaf-area per fruit for both the plum varieties was found to be different. Further work involving more severe thinning in heavy-bearing varieties like Beauty is indicated. Under Californian conditions also, Beauty demands more severe thinning than other varieties (Allen, 1929).

Thinning resulted in decreased yields of both the varieties under trial, but the results were statistically significant in the case of Beauty only. The losses in total yields have, however, been more than offset by better economic returns attendant upon

the extra large size of fruit and improvement in fruit quality. This is in accord with the findings of Levitt (1946), Ferrand (1903), Waring (1931) and Dickson (1931-32). The extent to which the fruit should be thinned has also been partially, if not fully, answered by the results reported in this paper. It has, for instance, been indicated that heavy-bearing varieties like Beauty would need to be more heavily thinned to get the desired results than what was done in these investigations.

The effect of thinning on the vigour of trees and the regularity in their fruiting were studied by recording the total annual shoot lengths as also the girth of limbs under the different treatments. The evidence clearly brought out the fact that limbs under the thinning treatments made significantly more growth in comparison with those where the crop was not thinned, showing thereby that thinning, among others, is an indispensable orchard practice to maintain the vigour of trees.

In addition to the quantitative effects of thinning on the vigour of limbs, as shown by the girth and total shoot length discussed above, the qualitative effects upon growth were also studied (Table XIV). It would be seen that the number of growths under

TABLE XIV. NUMBER OF GROWTHS FALLING IN VARIOUS LENGTH CLASSES UNDER EACH THINNING TREATMENT

Variety	Treatment	Average number of growths between												Total
		1-9 cm.	10-19 cm.	20-29 cm.	30-39 cm.	40-49 cm.	50-59 cm.	60-69 cm.	70-79 cm.	80-89 cm.	90-99 cm.	100-109 cm.	110-119 cm.	No. of growths
Santa Rosa	Control	222	22	12	9	6	3	2	..	1	1	1	1	281
	Light thinning	249	26	13	12	5	5	4	1	2	1	1	1	319
	Heavy thinning	255	21	9	9	5	3	2	1	2	1	..	1	312
Beauty	Control	509	20	14	3	3	..	..	..	..	..	..	..	547
	Light thinning	544	23	13	3	1	..	..	..	..	..	..	..	584
	Heavy thinning	547	28	16	5	4	1	..	..	..	..	..	..	610

10 cm. length was increased by the thinning treatments in both the varieties. Considering that the fruit is borne mainly on such short growths called spurs, it is evident that thinning resulted in the increased development of spurs for producing the crop in the following years. The evidence on hand has not only shown the outstanding effects of thinning for maintaining the vigour of trees, but has also clearly brought out its effect on the regularity of fruit production. Waring (1931), working with Lombard plum, reported that fruit thinning increased trunk surface, shoot length and shoot diameter. Thinning was also reported to increase fruit production in the year following thinning, but no explanation for this was given by him nor any data adduced in support of that conclusion. It is perhaps for the first time in this paper that a cogent explanation has been put forward in support of increased fruit production in the following year by trees subjected to fruit thinning. It is suggested that in future experiments on thinning

with plums, the effect of thinning upon the number of growths in different length categories should be studied in addition to the total shoot length and girth of trees.

SUMMARY AND CONCLUSION

A study was made at the Government Fruit Research Station, Kandaghat, concerning the effects of fruit thinning upon the size, fruit quality, cropping, etc., of Santa Rosa and Beauty (*Prunus salicina*).

The size of fruit increased in proportion to the severity of thinning in both the varieties. This has been shown to be due to the increase in the amount of pulp rather than the weight of stone.

The sugar content of the fruit was significantly improved by thinning, whereas the acidity progressively decreased with the severity of thinning.

Heavy thinning significantly improved the T.S.S./Acid ratio (taste) of the fruit as compared to light thinning and control in both the varieties.

Judged from the organo-leptic tests, the fruits under the thinning treatments were found to be far superior in colour and aroma to those under no-thinning.

Thinning reduced the yield of both the varieties, but the losses in yield were more than offset by better economic returns resulting from larger sized and better quality fruits.

The evidence regarding the increased girth and shoot length, resulting from thinning, leads to the conclusion that thinning is an indispensable orchard practice to maintain the vigour of Japanese plums.

Thinning increased the number of growths below 10 cm. length in both the varieties, resulting in increased development of spurs for producing the crop in the following year. The effect of thinning on the quality of growth, as shown by the present investigations, is a finding of outstanding importance to explain the regularity of fruit production by thinning.

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REVIEWS

Phenolics in Plants in Health and Disease. Edited by Pridham, J. B. Pergamon Press, Oxford, 1960. (ix+131 pp.)

This book is a report of the proceedings of the symposium on plant phenolics held at Bristol during April, 1959. The plant phenolics have both academic and economic importance and a great variety of simple and complex compounds possessing phenolic hydroxyl groups occur in plant tissues. Plant phenolics also play an important role in the study of the genetic control of biochemical reactions and are of considerable help in solving problems of botanical classifications. The proceedings of this symposium (divided into general subjects, lignification, pathology and genetics) have brought phenolics in the limelight and revealed that the role of these compounds during the life-cycle of a plant is becoming increasingly evident.

In the distribution of phenolic compounds in apple and pear trees Williams remarks that the phenolic patterns of the apple and pear trees show largely a quantitative variation of basic pattern of hyrdoxycinnamic acids, flavanols and flavanols, these compounds being present in any part of the tree. However, the nature of the major compounds was found variable from one tissue to another, phloridzin was found confined to the apple and arbutin to the pear. The former was specific to *Malus* and the latter to *Pyrus* and *Docynia*. In the hybrid (apple × pear) phenolic patterns appear to be superimposed. Pridham in the *Formation and Possible Function of Phenolic Glycosides* states that phenolic glycosides constitute a large and important group of naturally occurring compounds and that their highest concentrations are reported to be present in the cell sap of parenchymatous tissue. He reviews literature on glycosidic derivatives of phenols and remarks that a valid function of glycoside formation would appear to be detoxification of compounds which are harmful to the plant; that the toxic effects of some phenols could be considerably reduced by glycosylation of one or more hydroxyl groups, and that solubilization of phenolic compounds may possibly be another important aspect of glycoside biosynthesis. Further, that some plant glycosides may also be latent antimicrobic substances. He concludes that the true role of glycosides in plant tissue is still notvery well known. Spragg discusses the *Mobilization of Betanin in Beet root* and also records other pigments found in these roots. He found betanin and a yellow pigment as the two main pigments present in the roots. A third pigment, brown in colour, was also sometimes found in the roots, but unlike the other two pigments its molecule was not negatively charged. In the *Germination Inhibitors in Plant Material*, Sumere showed that coumarins and phenolic acids are distributed in seeds and other parts of plants, in yeast and spores of wheat stem rust, and discussed various aspects of the role of these compounds.

Roubaix and Lazar discuss the *Inhibitory Substances Contained in Sugar Beet Glomerules*. In the chromatographic examination of the aqueous extracts of sugar beet glomerules were found four organic acids:

P—hydroxybenzoic acid, vanillic acid, P—coumaric acid and ferulic acid.

These inhibited the germination of *Lepidium sativum* seeds. The anti-auxin action of these compounds and their physiological aspects are also discussed.

In some *Inter-relationship between Leuco-anthocyanins and Lignin in Plants*, Swain discusses the structure and biosynthesis of lignin, quantitative changes in the phenolic compounds of the plum, structure and biosynthesis of leuco-anthocyanins and comments on their inter-relationships. He concludes that the formations of lignin and leuco-anthocyanins are connected in respect of their mode of synthesis and the effect that light has on certain steps of this synthesis. Isherwood, in the *Formation of Lignin in Plant Tissues*, deals with the chemistry of lignin, its general structure and formation, and describes the techniques used by him to study these aspects.

Buchloh describes the *Lignification in Stock-scion Junctions and its relation to Compatibility* and concludes that the processes which are involved in the lignification of the cell walls are mainly responsible for the formation of strong unions in grafted pear quince trees, and remarks that the " lignification of the adjoining cell walls in the line of union may be one of the most important basic processes in stock-scion junctions which is responsible for the compatibility of the graft."

The *Metabolism of Aromatic Compounds by Fungi* is dealt with by Woodcock with particular reference to W-(2-naphthyloxy)—*n* alkylcarboxylic acids, phenoxy—*n*—alkylcarboxylic acid, 2-methoxynaphthalene and 3-indolylacetic acid and comments on the mechanism of hydroxylation. Flood and Kirkham discuss the *Effect of Some Phenolic Compounds on the Growth and Sporulation of Two "Venturia" species*, and remarks that phenolic host factors have an important bearing on the physiology of the scab diseases of apple and pear trees. The *Phenolic Substances in the Peel of Cox's Orange Pippin apples with reference to Infection by " G. perennans "* are dealt with by Hulme and Edney. They report that Chlorogenic acid inhibits, or at least modifies, the germination of *G. perennans* in culture, and that certain anthocyanidins influence the germination of spores of the species. Byrde, Fielding and Williams discuss the *Role of Oxidized Polyphenols in the Varietal Resistance of Apples to Brown rot*. They conclude that polyphenols form a defence mechanism against the brown rot diseases and also that extra cellular pectolytic enzymes of the fungus causing brown rot in apples may be inactivated by compounds which are not necessarily toxic *in vitro*. The *Inhibition of Plant Virus Infection by Tannins* is dealt with by Cadman. He remarks that the infection by various viruses alters the phenolic metabolism of plants.

Harborne discusses the *Genetic Variation of Anthocyanin Pigments in Plant Tissues*, with particular reference to hydroxylation, methylation, glycosylation and co-pigmentation with flavonols. Tabular information is provided on hydroxylation pattern of anthocyanidins, the mythylation of anthocyanins, the glycosidic classes of anthocyanidins, and anthocyanidin-flavonol relationships in *Primula sinensis*. The *Phenolic Constituents of Leaves and Flowers in the Genus " Lathyrus "* are dealt with by Pecket. Feenstra in the *Genetic Control of the Formation of Phenolic Compounds in the Seedcoat of "Phaseolus vulgaris"* L. discusses action of four of the many genes controlling pigmentation of the seedcoat in this species. The interaction between these genes is said to be complicated.

Pertinent literature and a short discussion are appended with each contribution. A general discussion is given at the close of each section. The discussions are lucid

and highly informative, and add greatly to the value of this symposium number.

A uniform policy has not been followed in abbreviating the titles of journals. There are few, if any, printing mistakes. The get-up of the publication is good.

The proceedings will be of particular interest and value to research workers in biochemistry and physiology and genetics of plants. It can also be usefully utilized by graduate students in botany and chemistry. (P.K.).

Proceedings of the Tenth International Conference of Agricultural Economics, 1958. Pages xii+535. *Oxford University Press, London*, 1960. Price not indicated.

The *Proceedings* cover the Tenth International Conference of Agricultural Economists held (for the first time in Asia) at Mysore from August 24 to September 3, 1958, and attended by about 300 members (many on their first visit to Asia) from 56 countries. The theme of the Conference was 'agriculture and its terms of trade' and, as elucidated in his address by Dr. L. K. Elmhirst (who has "devoted many years to India's problems"), the outgoing President of the Conference, "a consideration of the problems of balance between agriculture and other activities in the process of the economic growth of States and in the development of a sound world economy." The papers read and the discussions held at the Conference show that serious attention was given to the problems faced by India (earlier spotlighted by a thought-provoking address by the Prime Minister of India who inaugurated the Conference) and other countries on the march towards agricultural improvement.

The volume is rich in original thoughts in the field of agricultural economics, and the papers reproduced cover extensive ground: the shifting fortunes of agriculture; technical peculiarities of agricultural supply; changes in the demand for farm products; changes in the composition of farm inputs and farm outputs; the disparate stability of farm and non-farm prices; lack of institutional flexibility in agriculture; education, research, and extension in agricultural economics in Asia and Latin America today; using economics research in policy making; marketing, communications and transport; agricultural support measures; finance for development; rural population movements in relation to economic development; the interdependent development of agriculture and other industries; international organizations such as international agencies, commodity agreements and inter-regional groupings; planning procedures as adopted in India, Japan, Israel and the Union of Soviet Socialist Republics; and international co-operation in agricultural economics. Each of these aspects is competently dealt with by an authority, and the frank discussions at the end of every paper provide abundant food for thought for a student of agricultural economics.

The establishment of work groups (eight in number) was an innovation at this Conference. In fact, Dr. Elmhirst points out, "We have tried this year to reduce still further the reading of papers. Our struggles to avoid being smothered under an avalanche of paper readings have meant that invitations have gone out to many here, not to read papers but to make their contribution in discussion." Each member was asked to say which of the following subjects he would prefer to discuss: extension programmes; extension methods; farm management research; marketing research; undergraduate teaching; advanced teaching; general agricultural economic policy

and theory. In accordance with their replies, three groups were formed on policy, two on farm management and one each on extension, marketing and teaching, each group having a chairman, a secretary, two consultants and about 20 participants. The sessions of the work groups provided a good forum to the participants for a free exchange of views on subjects of mutual interest, and the resumes of work group reports are an interesting feature of the *Proceedings*.

The high standard of production of this 535-page volume is quite in keeping with the importance of the deliberations it records. A comprehensive index provided at the end is a great help.

It would not be out of place here to put in a word or two about the progress of the International Conference of Agricultural Economists. The representative character of the Conference, since it was inaugurated in 1929 when 50 economists from 11 countries met for two weeks at Dartington Hall, Devon, England, on the invitation of Dr. L. K. Elmhirst, has steadily grown. Today, the Conference has a total membership of 848, with 58 National or Area Groups, and embraces the majority of countries where the study of agricultural economics is pursued. The object of the Conference is to foster development of the science of agricultural economics and to further the application of the results of economic investigation of agricultural processes and agricultural organization in the improvement of economic and social conditions relating to agriculture and rural life. The meetings of the Conference, held every two or three years (no two successive meetings being held in the same country) afford a unique opportunity of personal intercourse to fellow-workers in the field of agricultural economics from all parts of the world.

—*H.K.S.*

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